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References to authors in the text must be made in the following way:—'According to Smith (1900) the spleen is enlarged, but Robinson (1914) says the reverse.' The references should be collected in alphabetical order of authors' surnames at the end of the paper, and arranged in the following way:—

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SMITH, J. (1900). 'Enlargement of the spleen in malaria.' *Journal of Pathometry*, Vol. I, pp. 1-20.

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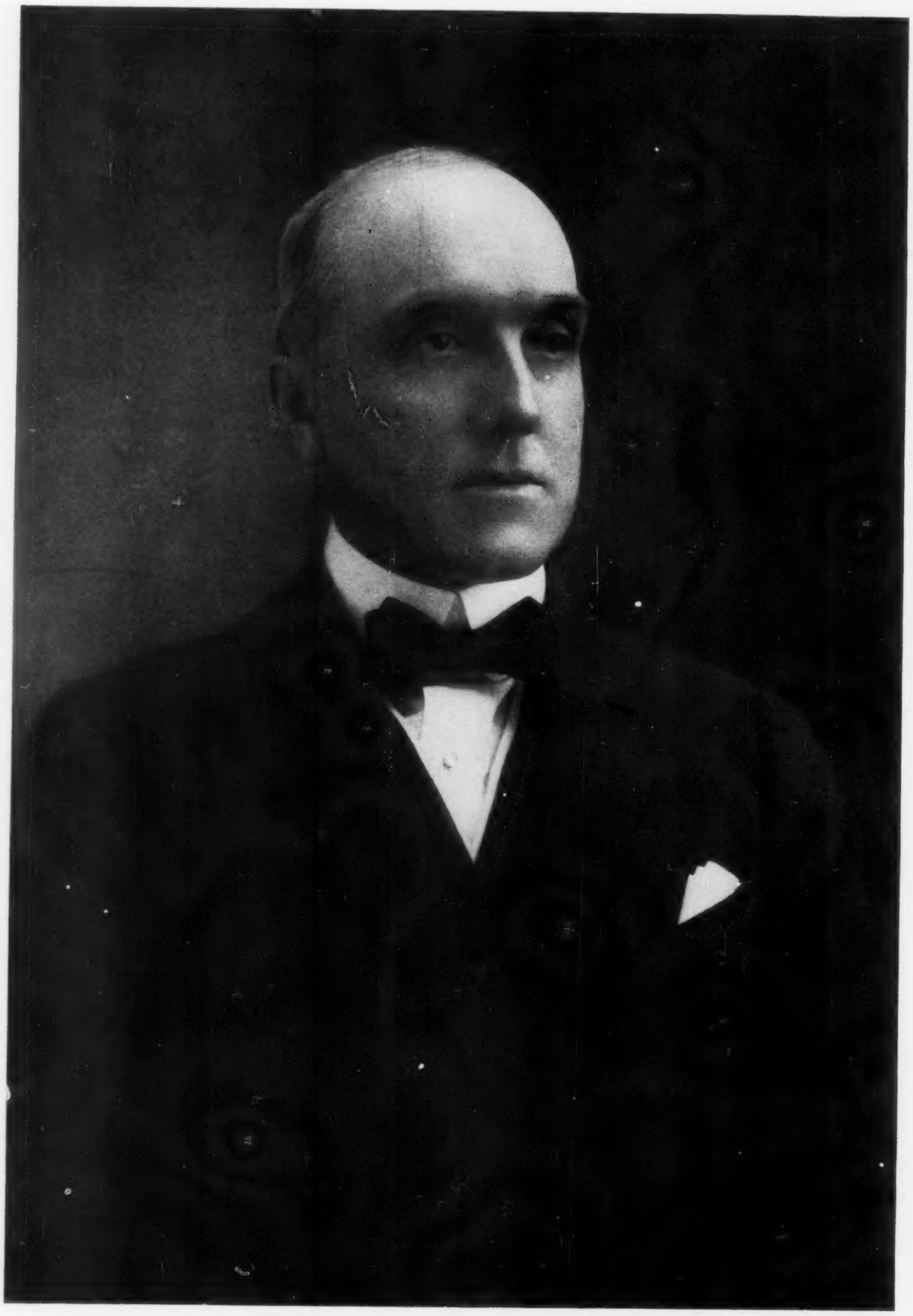

A. H. Milne.

In Memoriam

ALLAN HAY MILNE, C.M.G.

Allan Hay Milne, born in 1869, was the youngest son of the late Very Reverend A. J. Milne, LL.D., of Fyvie, Moderator of the General Assembly of the Church of Scotland. He was educated at Fettes College, Edinburgh, and Pembroke College, Cambridge. He entered the service of the Liverpool Chamber of Commerce in 1895, and was promoted to the Secretaryship in 1913. In 1911 he was made a Companion of the Order of St. Michael and St. George. He became Honorary Secretary of the School of Tropical Medicine on February 7th, 1899, and resigned his post through ill-health in October, 1917. He always devoted himself with conspicuous energy and success to the interests of the School, and his death on 21st January, 1918, left a vacancy which it will be difficult to fill. His bright, genial temperament and his intellectual attainments were always an attractive stimulus to those with whom he was associated.

We desire to record here our appreciation of these services, and to express our sense of the loss we have experienced.

NOTES ON BLACKWATER FEVER IN MACEDONIA

BY

J. F. GASKELL

From the 41*st General Hospital, Salonika*

(*Received for publication* 11 *March*, 1920)

I. INTRODUCTION

The nature of blackwater fever and its relationship to malaria and to the administration of quinine are questions at present undecided. The extensive work of Christophers and Bentley in India (1908), of Stephens (1903) in Africa and elsewhere, and especially the exhaustive investigations of Deeks and James (1911) during the building of the Panama Canal, furnish very strong evidence that blackwater fever is intimately related to malaria. They conclude that it only occurs when a population non-immune to malaria becomes exposed to extensive infection by it, when relapse and reinfection are therefore common, and owing to unfavourable conditions proper quinine treatment has not always been obtainable. Their observations also show that quinine has in a very high percentage of cases been the determining cause of the attack: where attacks have occurred when the patients have been under observation in hospital, the antecedent administration of quinine has been practically universal. The conditions quoted above were all present among the allied forces in the Balkan campaign of 1915 to 1918, and blackwater fever duly appeared. Conditions were especially favourable in the Serbian army, for not only was malaria a comparatively rare disease in Serbia, but also the army became highly infected when training at Salonika in 1916, and owing to various causes proper treatment often could not be given.

During the autumn and winter of 1917-1918, seven cases of the disease came under observation in the 41st General Hospital at Salonika. As they demonstrate certain points having bearing upon the above questions, I have thought it worth while to record them,

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more especially as the observations were made when completely ignorant of the literature of the disease, and thus afford independent confirmation of the views given above. Certain cases were under continuous observation in hospital for a considerable period, and suffered from repeated attacks of both malaria and blackwater fever, which could therefore be studied from their earliest stages. The 41st General Hospital acted as Base Hospital to the Serbian army from August, 1916, onwards, and six of the patients who suffered from blackwater fever were Serbians, the remaining case belonging to the hospital personnel. A further series of forty-six cases, mostly Serbians, have been recorded by Parsons and Forbes (1919), who state that their cases varied considerably in severity, but conclude that they were dealing throughout with a single disease, and that a separation into quinine haemoglobinuria and blackwater fever was not justifiable. The seven cases, with which this paper will deal, also varied considerably in severity, but were essentially of the same nature. Twelve attacks of blackwater fever occurred among these seven cases, eight taking place in the hospital itself and following rapidly upon the administration of quinine. The severity of the illness differed according to the nature of the treatment given. Even if some of the attacks here recorded can be considered examples of quinine haemoglobinuria, the fatal attacks, such as those of Cases 1 and 3, were also directly determined by the administration of quinine, so that quinine caused both blackwater fever and quinine haemoglobinuria.

The distinction between the two conditions would then merely lie in an arbitrary standard of severity of the attack, a severity which can undoubtedly be influenced by the treatment adopted. The assumption of a distinct condition of quinine haemoglobinuria is on the evidence of these cases a doubtful one, and the milder cases are rather to be looked upon, in accordance with the conclusions of Parsons and Forbes, as mild cases of blackwater fever. That such mild cases may finally die from a very severe attack is shown by a case recorded by Koch (1899). The patient, a sufferer from benign tertian fever, had had about ten attacks of haemoglobinuria which always followed the taking of quinine. He died within twelve hours from a final attack of blackwater fever, caused by the subcutaneous injection of half a gramme of quinine.

II. THE RELATIONSHIP OF MALARIA TO BLACKWATER FEVER

By the beginning of August, 1916, when British Base Hospitals were first provided, the Serbian army had become widely infected with malaria; and the great majority of the patients admitted to the 41st General Hospital during this autumn were suffering from the disease, often in a very severe form. Nevertheless, during the autumn and winter of 1916-1917, though some thousands of cases of malaria passed through the hospital, no cases of blackwater fever occurred. With the exception of a few cases in the early spring of 1917, the disease did not make its appearance in the Serbian army till the autumn and winter of 1917-1918, when the army had passed through two severe malarial seasons, and the great majority of the Serbs were sufferers from chronic malaria. Evidence of chronic malaria was present in all the cases of the present series; in all the spleen was enlarged and palpable during life, and a history of previous malarial attacks was obtained in all but two.

The coincidence of blackwater fever and the establishment of chronic malaria in a community hitherto practically free from both diseases supports the view that the relationship between them is intimate. Further, the absence of blackwater fever from the Serbian army during the first autumn and winter of 1916-1917 is most remarkable if the disease is an independent one, having no relationship to malaria, for the ground occupied by the Serbian army was practically the same throughout the two winters, and the conditions of existence were greatly improved during the second period. Susceptibility to a new and independent disease should therefore have been greater during the first season of 1916-1917, yet blackwater fever did not then appear. If, however, blackwater fever can only occur in patients with chronic malaria, the absence of the disease in the first season is explained, for malaria patients were then not sufficiently chronic to be susceptible. This evidence is, therefore, in favour of the view that blackwater fever only occurs in patients with chronic malaria.

The severity of the malarial attacks and the nature of the infecting parasite, whether benign or malignant, does not appear to be of importance. The disease was certainly not confined to severe infections with the malignant parasite, as many writers have

suggested; but, as was found by Koch (1899) and Deeks and James (1911) in the Panama Canal Zone, it was associated with both the benign and malignant forms, though the latter authors conclude that the benign is of comparatively little importance. In four of the seven cases, benign tertian parasites were found associated with definite malarial attacks. They were identified in Cases 4, 5 and 6 at the onset of subsequent malarial relapses (Table II), and in Case 7 in the malarial attack occurring the day before the onset of blackwater fever. The relapse in Case 4, in which benign tertian parasites were found, was also followed by an attack of blackwater fever. In the remaining three cases no parasites were found, as films were not examined until after the onset of the fatal attack. No parasites have been found in this series when blackwater fever has become established. This should not, however, be taken to mean that blackwater fever has no relationship to malaria, but is rather to be interpreted in the light of cases, such as numbers 4 and 7 in this series, in which parasites were found immediately before the blackwater fever attack, but disappeared when the attack took place. The probable explanation of the absence of malarial parasites in the peripheral blood during an attack of blackwater fever is that the attack itself destroys them.

The degree of malarial cachexia present is obscured by the jaundice and anaemia due to blackwater fever itself, but in some of the cases of this series the cachexia was certainly not great, as they were not wasted to the extent which is then found. Patients suffering from a comparatively mild degree of chronic benign tertian malaria were, therefore, susceptible to blackwater fever as well as those with the more severe forms of malaria.

To sum up, blackwater fever in Macedonia was always associated with chronic malaria, which was not, however, necessarily of a severe type.

III. SEASONAL PREVALENCE

Six of the seven cases occurred between October, 1917, and April, 1918. Three of these had further attacks, which also took place within this period. This agrees with the seasonal incidence observed by Parsons and Forbes, the great majority of whose cases

occurred during the same period. The disease was, therefore, a winter one, and appeared when, owing to exposure to cold, malarial relapses were common, but fresh infection by malarial parasites did not take place. As the hospital consisted throughout its existence of tents only, patients could not be protected from the cold, and in consequence malarial relapses were frequent. The common history was a chill which brought on a malarial relapse, with which the attack of blackwater fever was associated. After April, 1918, no further cases of blackwater fever had occurred up to the end of August. The winter prevalence of the disease was thus very definite, and exposure to cold appeared in many cases to be a determining factor.

IV. THE RELATIONSHIP OF QUININE ADMINISTRATION TO THE ATTACK OF BLACKWATER FEVER

The particulars of the eight attacks of blackwater fever which occurred in the hospital are given in Table I. The time relationships of the doses of quinine given and the onset of the attack of black-water fever are shown, as far as they could be ascertained, in the charts at the end of this paper. The attacks, with the exception of the third known attack of Case 2, all quickly followed the beginning of a course of quinine treatment in the hospital. The third attack of Case 2, which occurred six days after the second attack, took place while the patient was undergoing a full course of quinine, which consisted of 160 grains given intramuscularly spread over the first five days, and 30 grains per day orally on each of the following days. Quinine was therefore being administered in quantity when this attack took place. This third attack was so severe that the patient died before haemoglobin had appeared in the urine. It was substantiated by the discovery of haemoglobin in quantity in the kidney tubules after death.

Case 1 developed blackwater fever on the third day after admission, when he had undergone two days of the intramuscular course usually given. He gave a history of malarial attacks every other day for the ten days preceding admission, and stated that he had had quinine by mouth every day. The amount given must however have been small, as the malarial attacks were not controlled

and the patient's temperature was 100° on admission. The other attacks given in the table all rapidly followed the administration of quinine given on account of an attack of malaria. In one case only was the malarial attack doubtful, namely, in the second attack of Case 6. This patient was admitted suffering from his primary attack 14 days before, and, though this attack of blackwater fever passed off, his temperature did not fall to normal (Chart VI). Notwithstanding the fact that blood films were all found negative it was thought possible that the raised temperature was due to malignant malaria. A modified course of intramuscular quinine of 20 grains daily was decided upon, which brought on the second attack of blackwater fever on the third day. As subsequent malarial attacks proved that the case was one of benign tertian malaria, parasites should have been easy to find in the blood in any attack, but as the patient suffered from pyorrhoea, and an abscess subsequently declared itself at the site of a subcutaneous saline injection given shortly after admission, the temperature chart is probably explainable from the two last causes. The point is of interest because this attack would then be due to the administration of quinine only, and not to the combination of quinine and a fresh malarial attack. That is to say, an attack of blackwater fever can be brought about in a patient with chronic malaria by the administration of quinine, without the additional factor of an acute malarial attack. A similar case is recorded by Deeks and James (1911).

The initial attacks of Cases 2 and 4 occurred before admission to the hospital, and particulars regarding quinine administration were only vaguely obtained. Case 2 was admitted to a casualty clearing station on the third day of an attack of malaria and was given doses of 15 grains of quinine orally two days later, on which day blackwater fever declared itself. It is improbable that more than two doses, that is to say 30 grains, were given before the attack of blackwater fever. The initial attack of Case 4 occurred over a month before admission, and no details of quinine administration could be obtained. That quinine had relationship to the attack is, however, almost certain, as the patient stated that no quinine had been given him in the hospital from which he was transferred, and, though put on quinine on admission, he refused to take it for three days. He had presumably been instructed to this effect in

his previous hospital, but a satisfactory history was extremely difficult to obtain: it was only discovered that he had had an earlier attack after his second attack had declared itself. Cases 5 and 6 were admitted respectively on the second and third day of their primary attack of blackwater fever. Case 5 had been in our hospital six months before with malaria, and had had an illness with raised temperature for five days before the onset of blackwater fever. It is thus almost certain that he had taken quinine for this illness. Case 6 stated that he had been taking quinine irregularly for thirty days before blackwater fever began. There is thus presumptive evidence that these four initial attacks were related to the administration of quinine. In no less than three of these four cases subsequent administration of quinine rapidly produced further attacks, which gives additional support to the view that the primary attacks were caused in the same way.

The study of these seven cases thus shews an extremely close relationship between the administration of quinine and an attack of blackwater fever. All were cases of chronic malaria in whom relapses occurred, with only one exception, during the winter months; in all quinine was the final factor which determined the attack.

V. THE CRITICAL DOSE. QUININE TOLERANCE

The method of quinine administration in use throughout the hospital consisted of either 30 grains daily by mouth or 20 grains intramuscularly every morning and evening. The amount of quinine administered either by mouth or by the intramuscular method before the attack of blackwater fever is shewn in each case, where it was accurately known, in the last column of Table I, and varies from a single dose to a number of doses spread over two or three days. The amount necessary to produce blackwater fever was therefore different in each case, varying from 20 grains in Case 2 to 80 grains in Case 1. This variation gave rise to the idea that each patient susceptible to blackwater fever had a critical dose which produced the disease, and that smaller doses could be tolerated by him without ill-effect. This view has been already advanced by

Ziemann (1906) and Nocht (1905); the latter also maintains that tolerance can be built up by judicious quinine treatment. Cases 1, 2, 3 and 7 never became convalescent, so that the point could not be tested, but Cases 4, 5 and 6 all recovered and had subsequent malarial attacks, some of which were successfully treated by quinine without the recurrence of blackwater fever. The details of these are given in Table II.

It will be seen from Table I that Case 4 was unable to tolerate a dose of 30 grains without getting blackwater fever, whether it was administered orally or intramuscularly, but it will be seen from Table II that two subsequent attacks of malaria were, however, successfully treated by giving 10 grains a day, in the first instance intramuscularly, in the second, orally. Case 5 had many attacks of malaria in the hospital, and was able to tolerate a dose of 20 grains a day. Case 6 got a second attack of blackwater fever after three days' administration of 20 grains intramuscularly, but a subsequent malarial attack was successfully treated by 10 grain doses. The tolerance to quinine, therefore, varied in the three cases, but doses were found which the patient could tolerate in each case.

VI. THE EFFECTS OF QUININE ADMINISTRATION WHEN BLACKWATER FEVER HAS BEGUN

A full course of quinine administration was continued in the first three cases till death took place. Some quinine was also given after the onset of blackwater fever, in Case 5 who was extremely ill, and in Case 7 who died. In the other two cases (4 and 6) quinine was stopped directly signs of blackwater fever appeared, and none of their attacks shewed dangerous symptoms, but were quickly recovered from. Case 2 lived sufficiently long for a full course of quinine to be given, and though suppression of urine did not take place, was extremely ill, lying after the second day in a drowsy, apathetic condition. A third attack of blackwater fever just one week after the second was immediately fatal.

Case 5 was given 20 grains of quinine intramuscularly for two days after his admission on the second day of an attack of black-

water fever. He suffered from marked suppression lasting about a fortnight, and his illness was very severe.

Case 7 was given 30 grains intramuscularly on the day following the onset of blackwater fever, which had not then been discovered. He rapidly developed suppression which became complete, and he died on the fifth day notwithstanding the copious administration of fluids by every possible means. From the evidence of these cases the continued administration of quinine would appear to be most dangerous.

VII. COURSE OF ILLNESS

The onset of the attack was in some instances marked by a rigor, and the second attack of Case 4 probably dated from a fainting fit at 10 p.m. on the evening of February 7th. In other instances, the exact time of onset could not be accurately ascertained. The first appearance of haemoglobin in the urine probably occurs at a varying period after haemolysis has taken place, and is, therefore, not an accurate measure of the onset. In the final attack of Case 2 haemoglobin had not even reached the bladder when death took place, but was still confined to the kidney tubules. In some of the attacks here recorded, the first specimen of urine containing haemoglobin was the first passed that day, so that the true beginning of the haemolysis was even more vague, for it might have occurred at any time during the night. The onset of haemoglobinuria shewn by the thick line on the charts can, therefore, only be regarded as approximate. During the first day of the attack, even in the fatal cases, the general condition of the patient did not appear to be dangerous; for instance, Case 7, the hospital orderly, was under treatment for a malarial attack in his own tent, and did not feel sufficiently ill to ask for admission into a hospital ward until the second day of his illness. In the severe cases mental confusion and drowsiness became marked on the second day, often accompanied by an increase of the vomiting which had usually begun on the first day; vomiting was, however, completely absent in Case 2. A rapidly increasing jaundice was present in all cases, accompanied in the more severe by marked collapse with a feeble rapid pulse.

VIII. THE EXCRETION OF HAEMOGLOBIN AND OF ALBUMEN

The excretion of haemoglobin in the urine did not last many days in any attack, even when suppression was present. In the second and third attacks of Case 4, and the second attack of Case 6, which occurred in the hospital when these patients were being carefully watched and treated, haemoglobin disappeared from the urine within twenty-four hours. Even in Case 5, with marked suppression, haemoglobin disappeared four days from the onset; in the second attack of Case 2, where the general condition was very serious, although no suppression took place, the haemoglobin was all excreted within forty-eight hours. In this series, therefore, haemolysis, of which haemoglobinuria was a sequence, was complete within a comparatively short time, even though the clinical condition remained severe, and whether quinine was continued or not. Suppression became acute on the fourth day in Case 5, but, nevertheless, haemoglobin ceased to be excreted after that date. This shows that an almost complete loss of excretory power by the kidney does not cause excess of haemoglobin to be retained in solution in the blood. In Case 5, the last dose of quinine was given the day before haemoglobinuria ceased, but Case 2 shows that the cessation of quinine administration is not the cause of cessation of haemoglobin excretion, for here quinine was continued throughout, and yet haemoglobin disappeared from the urine in two days. In Case 2, however, the continued administration of quinine was accompanied by another attack of haemolysis seven days after the onset of the second attack. Haemolytic conditions had again been built up owing to the continuous supply of quinine to the blood.

The excretion of albumen was in every case continued after the excretion of haemoglobin had stopped. Its persistence was directly dependent upon the severity of the illness. In the second and third attacks of Case 4 it only lasted for four days, and in the second attack of Case 6 for seven days. In the more severe first attack of this case it lasted for twelve days. In the very severe attack of Case 5 with marked suppression it lasted for no less than sixty days.

IX. SUPPRESSION OF URINE AND THE CAUSE OF DEATH

Suppression was present in two cases, one of which was fatal. In both it reached its maximum on the fifth day, being complete in the fatal one, Case 7, while in the other, Case 5, the amount of urine was reduced to only $2\frac{1}{2}$ ounces.

Cases 1 and 3 died on the second day with a diminished output of urine. The third attack of Case 2 was so rapidly fatal that suppression could not have declared itself; the second attack of this case, though severe, was not accompanied by suppression.

Case 5 illustrates the time required for recovery from this dangerous complication; the process was gradual and the urine did not reach a normal amount for fourteen days, slowly increasing from its minimum on the fifth day. The condition of this case was still extremely critical for the fortnight following the recovery of full excretory power. Death in Cases 1, 2 and 3 was toxic in nature and too rapid for suppression to become manifest, though it would in all probability have occurred if the patients had lived longer, for the tubules of the kidney in Case 2 were distended with freshly excreted haemoglobin-stained material, and diminution of the amount of urine had already occurred in the other two cases. In Case 7 death rapidly followed the complete suppression of urine. Through the kindness of Captain Forbes, I was able to examine the kidneys of a number of other cases who had died with suppression of urine. The condition found was a complete obstruction of the kidney tubules, chiefly in the region of the loops of Henle, by plugs of coarsely granular material giving the haemoglobin reaction with eosin. The first convoluted tubules above the point of obstruction were dilated, but their epithelium was well preserved. The cause of suppression is thus a mechanical one. Warrington Yorke and Nauss (1911) have shewn that a similar condition can be produced experimentally by the injection of haemoglobin into the blood stream under conditions of diminished blood-pressure. The literature of the subject shews that suppression is the chief complication to be feared, if the toxic effects of the attack are not in themselves fatal.

With the exception of an extreme liquidity of the blood and the absence of malarial parasites and the changes in the kidney, the

fatal cases did not show post-mortem either macroscopically or microscopically any changes which are not met with in malaria. I have made an extensive series of investigations in malaria which are being published in the *Quarterly Journal of Medicine*, in which all the histological changes recorded by Whipple (1909) in blackwater fever have been found. The absence of malarial parasites in the tissues shows how complete is their destruction by the blackwater fever attack.

X. TREATMENT

In order to prevent the occurrence of suppression by the blocking of the kidney tubules, treatment should be directed to the administration of fluid in quantity, and at the same time collapse should be combated by the usual methods in conjunction with the administration of brandy and injections of strychnine. The experiments of Warrington Yorke and Nauss (1911) demonstrate the importance of the maintenance of blood pressure. In treating the earlier cases of this series the importance of the administration of fluids was not recognised. In Case 1, subcutaneous saline injections were only given very shortly before death, when the condition was desperate, and in Case 3 no extra fluids were given. Case 2 was given as much fluid as possible by mouth, but none by any other method. This treatment was begun in the early stages of his second attack, and possibly had considerable influence in preventing the occurrence of suppression. Case 5 was not given any great quantity of liquid until suppression had already set in on the fourth day of his illness; he was then, however, treated energetically both with rectal salines and as much fluid as possible by mouth, so long as suppression was still present. It is possible that in this case treatment by fluid in quantity begun on the day of admission might have averted the attack of suppression, but that the belated application of this treatment, nevertheless, enabled recovery to take place.

Cases 4 and 6 were treated from the earliest possible stage both with subcutaneous and rectal saline injections, and with as much fluid as possible by mouth. The importance of treatment by fluids, directly the first signs of blackwater fever occur, cannot be too greatly emphasised. This treatment should never be withheld

until signs of suppression appear; coagulation has then already taken place in the kidney tubules and the plugs cannot be dislodged. The object of fluid treatment is to dilute the excretions of the blood so as to prevent coagulation taking place.

XI. CONCLUSIONS

The details of the above cases support the view that the pathology of blackwater fever consists in the sudden occurrence of an extensive haemolysis in the blood stream brought about in certain cases of chronic malaria by the administration of quinine; exposure to cold is usually a contributory factor. The haemolysis is essentially chemical in nature and is completed within a comparatively short time, being in this respect very comparable to the haemolysis of paroxysmal haemoglobinuria. The excretion of the haemoglobin liberated can be successfully accomplished so long as it does not pass through the kidney in a too highly concentrated form. If it is too concentrated coagulation takes place in the loops of Henle, and suppression of urine occurs, which is usually fatal. Continuation of quinine administration increases the toxic conditions set up by the attack of blackwater fever and also increases the probability of suppression, though it does not appear to prolong greatly the period of actual haemolysis. Treatment should, therefore, be directed to the prevention of collapse and the dilution of both the haemoglobin and toxines by the administration of fluids in quantity by every available method. Quinine should be stopped immediately the blackwater fever is discovered; its further administration is both dangerous and also unnecessary, for the blackwater fever attack itself destroys the malarial parasites in the circulation.

In any particular patient a critical dose of quinine is necessary to produce an attack of blackwater fever; malarial attacks in such a patient can be successfully treated by doses below this limit.

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TABLE I.

Shewing the relationship of quinine administration to blackwater-fever.

Case.	Attack of B.W. Fever.	Duration of malarial attacks before onset in days.	Number of days of quinine treatment preceding the attack.	Total amount of quinine in grains.	Remarks.
1. ...	1st	13	$*10^{0} + 2^{1}$	80 +	Amount orally in first ten days unknown, but certainly small.
2. ...	2nd	9	1^{1}	20	
	3rd	15	$5^{1} + 3^{0}$	250	Quinine continued after attack. Haemoglobin in kidney only.
3. ...	1st	2	1^{1}	40	
4. ...	2nd	2	1^{0}	30	
	3rd	2	1^{1}	30	
6. ...	2nd	0	3^{1}	60	Malarial attack very doubtful.
7. ...	1st	2	2^{0}	50	

$*10^{0}$ = ten days' oral treatment.
2^{1} = two days' intramuscular treatment.

TABLE II.

Critical Dose of Quinine.

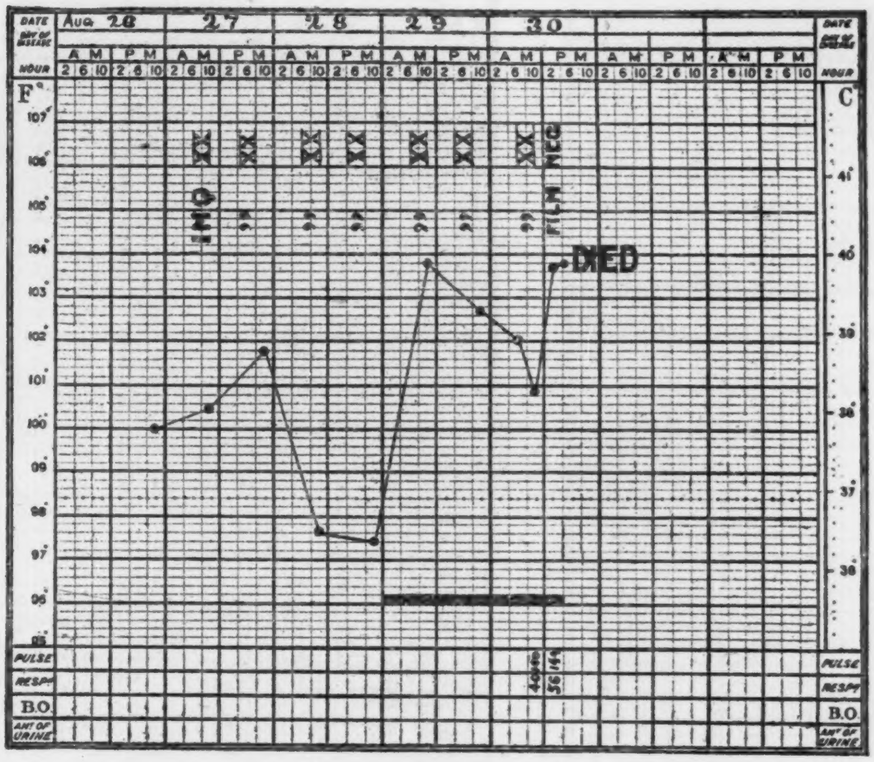
Case	Date of malarial attack.	Number of attack of Black-water fever.	Blood Film.	Dose in grains.	Number of days.	Total amount given.
4.	1918. Feb. 7	2nd	—	*X^{o}	1	30
	Feb. 26	3rd	B.T.	XX^{1} (first dose) X^{1} (subsequent dose.)	2	50
	April 2	—	B.T.	X^{1}	6	60
	April 25	—	B.T.	V^{o}	3	30
5.	Feb. 18	—	B.T.	XX^{1} (first dose.) X^{1} (subsequent dose.)	4½	90
	Mar. 11	—	Neg.	XX^{1}	3	60
	April 1	—	B.T.	XX^{1} (first dose.) X^{1} (subsequent dose.)	3	60
	April 5	—	B.T.	XX^{1}	2	40
	April 24	—	B.T.	X^{o}	3	60
6.	Malaria doubtful.	2nd	—	XX^{1}	3	60
	April 25	—	B.T.	X^{1} (first dose) V^{o} (subsequent dose.)	3	35

X^{o} = grains 10 orally.
XX^{1} = grains 20 intramuscularly.

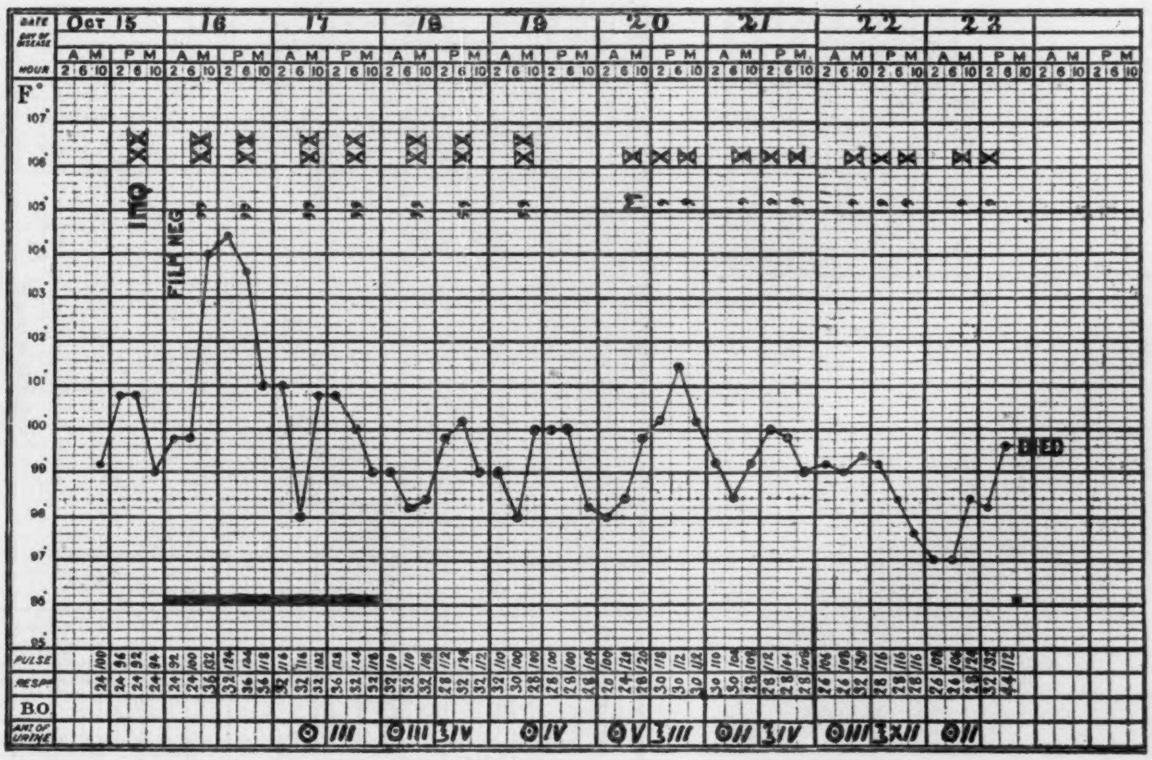
EXPLANATION OF CHARTS

The thick black line shows the duration of the blackwater fever attack.

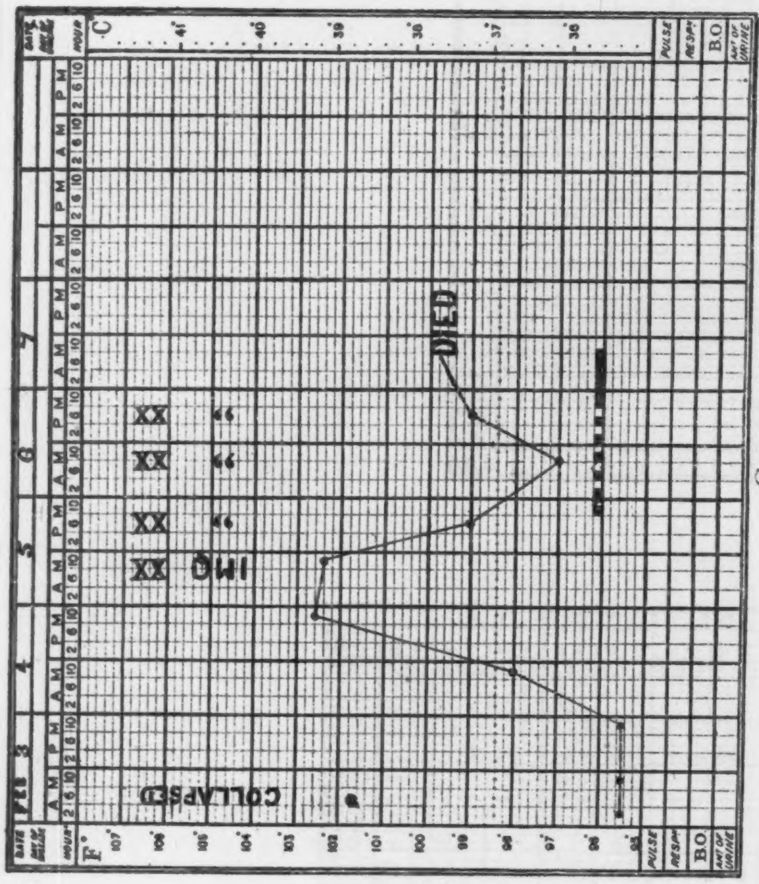
I.M.Q. = quinine intramuscularly.
M. = quinine orally.



CASE 1



CASE 2



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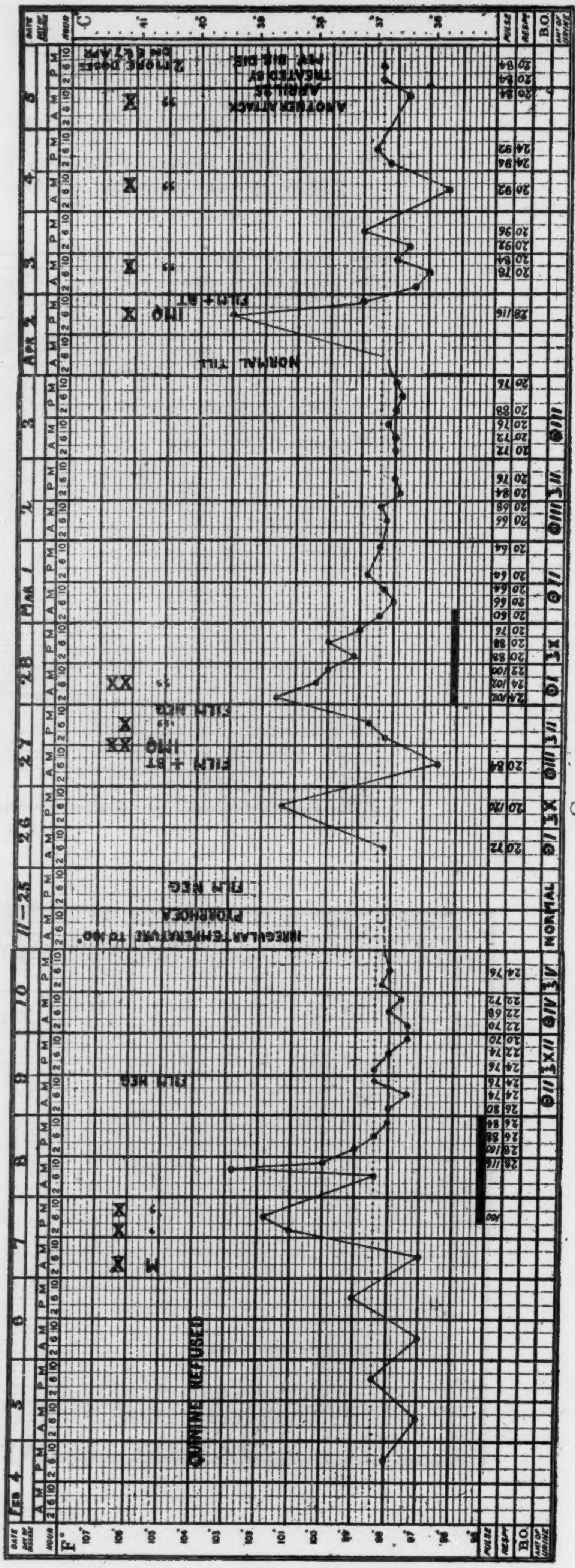
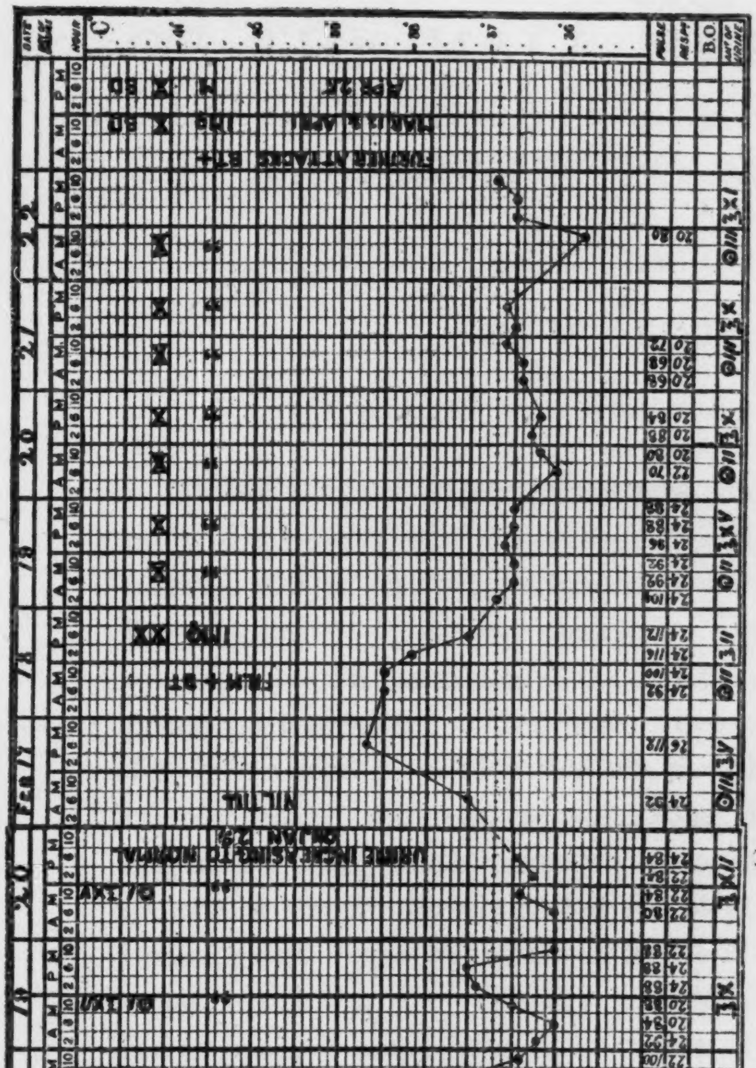
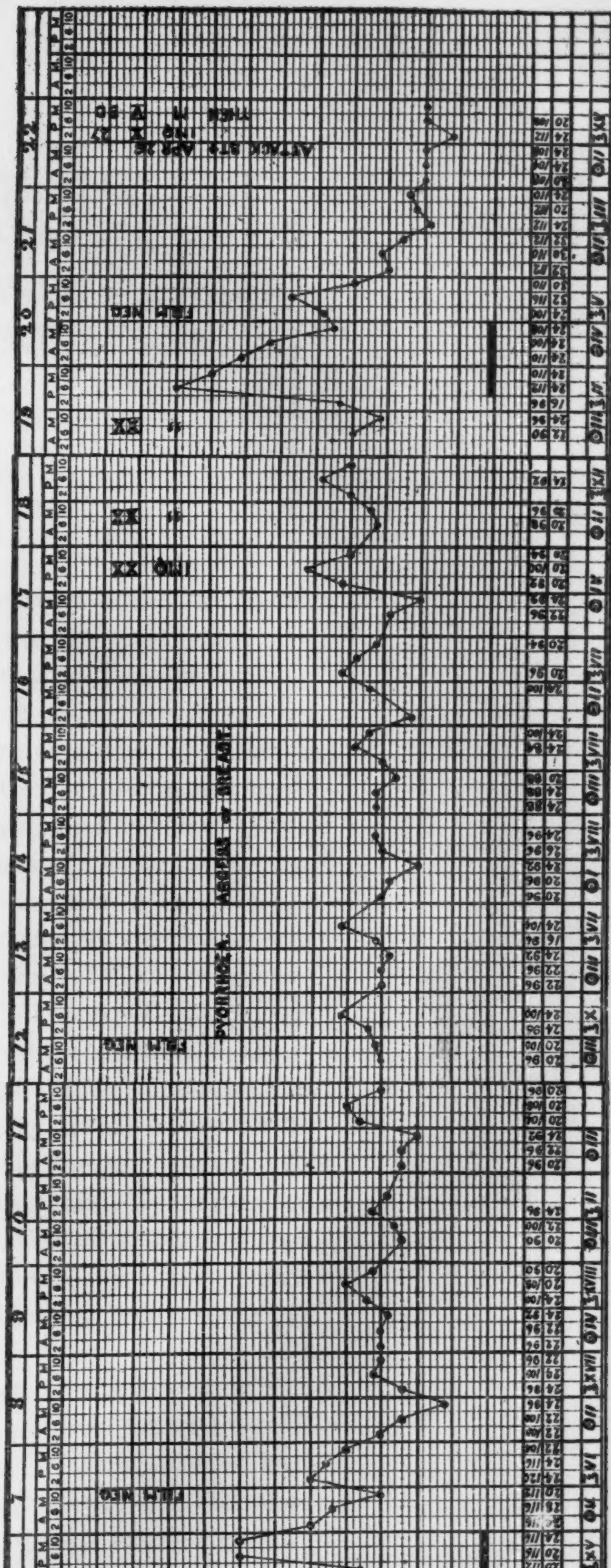


CASE 4



Case 5



Case 6

THE NOMENCLATURE OF THE PARTS OF THE MALE HYPOPYGIUM OF DIPTERA NEMATOCERA, WITH SPECIAL REFERENCE TO MOSQUITOES

BY

F. W. EDWARDS

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It has long been recognised that the structure of the tip of the male abdomen is of the greatest importance in the classification of insects, and an enormous amount of work has been done in figuring the organs in different species. Unfortunately, however, the greatest diversity and confusion exists in the naming of the different parts, and nowhere is this more apparent than in the mosquitoes. The terms used for the lepidoptera have been applied to these insects in altogether different senses from those in which they were originally used, and, moreover, have been used even in different genera of the family Culicidae for structures which are clearly not homologous. The writer hopes in the notes which follow to indicate terms which can be generally adopted for all mosquitoes, and as far as possible those have been chosen which are applicable to other Diptera, if not also to other orders of insects. Since, however, the mosquitoes are amongst the most generalised Diptera in regard to genital structure, it must not be expected that the same terms will all apply to the highly specialised Brachycera and Cyclorrhapha. Reasonable allowance has been made for the claims of priority, but it has not been considered advisable to follow a rigid rule in this respect, and the name judged most suitable has been chosen in each case.

Of the many writers who have concerned themselves with the genitalia of mosquitoes, the only one who appears thoroughly to understand the subject is Christophers (1915). This author has given an accurate analysis of the parts in *Anopheles*, and has also pointed out the existence of a very remarkable and extremely

important phenomenon: that in *all male mosquitoes,* shortly after the emergence of the adult, the tip of the abdomen undergoes torsion through an angle of* 180°, so that the parts which are morphologically ventral become dorsal, and *vice versa.* It is probably failure to appreciate this fact that has led to most of the confusion in regard to the naming of parts; certainly such a failure has caused Brolemann (1919), the latest writer on the subject, to speak of the genital chitinisations as the 'cylindre perianal,' and the anal sclerites as the penis.

Good as Christophers' work was, it dealt only with *Anopheles,* where all the parts are not well developed, and so requires supplementing and slight modification.

Before proceeding further, it will be well to state the now universally accepted fact that the hypopygium of mosquitoes,† as of all but the more specialised metabolic insects, is composed of four distinct parts‡:—

(1) A more or less continuous chitinous ring, representing the tergite and sternite of the ninth abdominal segment.

(2) A pair of appendages of the ninth segment, more or less ventral in position (except secondarily in mosquitoes).

(3) Chitinised pieces surrounding the anus.

(4) Chitinisations of the genital tube, as opposed to the main body wall, which forms the other three parts.

We will discuss each of these elements in some detail.

(1) THE CHITINOUS RING OF THE NINTH SEGMENT. This is spoken of by Lepidopterists as the *tegumen,*§ the term having been introduced by Buchanan White (1878) and its use modified by P. H. Gosse (1883). Although in a great many insects, including

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* Females are not so affected, but the phenomenon is not confined to the males of Culicidae. It occurs also in the males of Psychodidae (in *Phlebotomus* and probably others) and Dixidae, and also in the Tipulid genera *Molophilus* and *Rhypholophus.*

† The present writer, in common with some others, has frequently spoken of the 'genitalia.' This term, however, should perhaps be confined to the chitinisation of the genital tube. *Hypopygium* is on the whole the best, used in the sense in which Snodgrass (1904) employed it, to include the four elements distinguished above; it is, however, not very appropriate for the Nematocera where the structures are terminal, not ventral as they are in Brachycera and Cyclorrhapha. Other terms in use by different writers are *male armature* and *copulatory apparatus,* but these seem less satisfactory.

‡ In a few cases the eighth abdominal sternite undergoes special development in the male, constituting a fifth element, but the occurrence is so rare that it may be dismissed with a mere mention. In any case there is no ambiguity about the term eighth sternite.

§ Not to be confused with the *tegmen* of the Coleopterists, which has an entirely different signification.

mosquitoes, it forms a continuous ring, yet this is not always the case, and even where it is, the ring is very much narrowed at the sides, leaving differential dorsal and ventral portions between which it is often possible to find traces of a suture. There seems, therefore, no need for the term tegumen, and it will be preferable to speak, as most writers on the hypopygium of Diptera now do, of the *ninth tergite* and *ninth sternite*.

The true ninth tergite is ventral in position in mosquitoes, as explained above. It is generally more or less distinctly bilobed, the lobes bearing bristles or spines, but its form varies greatly in different genera. I have used (1914) the morphologically incorrect term 'ninth sternite' for the whole structure; its lobes are the *setaceous lobes* of Felt (1905) and the *basal appendages* of Howard, Dyar and Knab (1912). This last term is inadmissible since the structures are not appendages. No objection can be raised to Felt's term, except that it is unnecessary. I propose to call these parts the *lobes of the ninth tergite*. The fact that they have sometimes been referred to as the lobes of the ninth *sternite* need cause no confusion, because the true ninth sternite is not usually lobed. These lobes have not been used as much as they might be in specific and even generic descriptions. Their most primitive form is seen in *Megarhinus regius*, where the tergite is broad, and without any emargination at the tip. In *Anopheles* and *Aëdomyia* the tergite is barely discernible and carries no bristles. In *Aëdes* a pair of lobes are well developed, each nearly as long as broad, and bearing a row of spine-like bristles. The Sabethini show considerable specific differences, but the lobes are generally much more elongate than in *Aëdes*, though sometimes shorter. In *Culex* they are broad and short and the terminal bristles are more hair-like. In some forms (*e.g.*, *Uranotaenia pallidocephala*, *Armigeres obturbans*) the bristles are absent.

The ninth tergite is well developed and obviously distinct from the sternite in most families of Nematocerous Diptera, and often, particularly in the genus *Tipula*, exhibits most diverse specific modifications. In Cyclorrhapha, through the atrophy of the eighth or pregenital segment of Awati (1915) it is apparently the eighth: it is very large and folded back under the abdomen, covering the anal and genital parts. In *Phlebotomus* it is almost completely divided

into two elongate lobes, which Newstead (1911 *b*) has called the inferior claspers.

The true ***ninth sternite*** has been incorrectly spoken of by me (1914) as the ninth tergite, and equally incorrectly by Leicester (1908) as the sur-anal plate. It exhibits fewer modifications in the Culicidae than does the tergite, being usually represented by a narrow strip of chitin. In some *Anopheles* it is apparently absent; in *Culex perfidiosus* it is greatly enlarged; in a few species of *Aëdes* (sub-genus *Aëdes*) it has developed lateral processes, and in some forms it is strongly emarginate at the tip. It usually bears a few bristles about the middle, and in *Armigeres obturbans* is chitinised only at the sides and round these bristles.

The ninth sternite is well developed in most Limnobiidae, and in *Trichocera*, but in Psychodidae and some Mycetophilidae it is not distinguishable; in many other Mycetophilidae, in Bibionidae and in *Tipula*, it is very large and forms a single piece with the basal joint of the forceps (see below). In Cyclorrhapha it is said by Awati (1915) to be absent, but may possibly be represented by his vesiculum or by the editum of Newstead (1911 *a*). However, it is very difficult to homologise the part of the Nematocera with those of the Cyclorrhapha, and it is beyond the writer's intention and competence to do so.

(2) THE APPENDAGES OF THE NINTH SEGMENT. In all mosquitoes, as well as in the majority of the more primitive Diptera, the ninth segment bears a pair of two-jointed* appendages, which articulate with the ninth sternite, usually at its attenuated sides. Appendages of the ninth sternite occur in other orders of insects; they are universal in Lepidoptera, where the term *harpagones* was proposed for them by Buchanan White (1878); by P. H. Gosse (1883) they have been styled *valves*, and by some Lepidopterists *harpes*. The first and third of these terms have been used in varying and contradictory senses by writers on Culicidae, but never for the appendages of the ninth sternite; they are not in use by other Dipterists, and it is inadvisable that they should be retained. The term valves is quite inappropriate, at least in regard to the Diptera, and it also must be rejected.

* Three-jointed if the terminal spine is reckoned as a joint.

The term *forceps* (*forcipules* of the French writers, *Zange* of the Germans) has frequently been employed, and will be useful when it is desired to speak of the whole appendages.

(*a*) *The basal joint.* The homology of this piece is uncertain. By many it is regarded as simply a specialised part of the ninth sternite, and there is much to be said in justification of this view. As stated above, in many Nematocerous Diptera, including most Mycetophilidae and Bibionidae, the part cannot be distinguished from the ninth sternite, though it is quite possible to argue that this may be due to a secondary fusion. The apical part of the sternite in these cases has usually a median furrow or slit which may indicate either incipient division or incomplete fusion. Another point to be noted is that in some cases where the ninth sternite is apparently separate from the basal joints of the forceps, these latter are connected at their bases ventrally (*e.g.*, *Trichocera*, *Macrocera*). In Limnobiidae the sternite and basal joints of the forceps are usually well separated.

In view of the uncertainty as to the exact homology, and pending further investigation and discussion, it will perhaps be as well to avoid using the term 'basal joint of forceps.' This is the more desirable since other terms are in use by students of Nematocera. Snodgrass (1904) proposed *pleuron*, while Dyar and other writers on the Culicidae speak of it as the *side-piece*. Both these terms are good, but Snodgrass's suggests the implication that it is derived from a separate pleural piece analagous with the thoracic pleura: perhaps a correct assumption, but as yet unproven. *Side-piece* is more non-committal, and is widely used by writers on Culicidae. There seems, therefore, to be no occasion for replacing it.

This part is subject to many important modifications in the different genera of the family. In most it has the form of a hollow chitinous tube, widely open at the base, especially on the inner side, and tapering more or less to the tip. Sometimes, however, the chitin is discontinuous on part or the whole of the inner aspect of the tube, where the wall may be formed of thin membrane only. *Anopheles* and *Chaoborus* have the tube complete, or almost so; some lacunae of chitinisation appear in some of the early Culicine genera, notably *Megarhinus*, the final stage being reached in the *Aëdes* group, of which it is highly characteristic. Here the side-

piece forms a *lower flap** (ventral in actual position) and an *upper flap* (dorsal) connected on the outside by chitin and on the inside by thin membrane, which extends right up to the tip.

The apical and basal lobes of the side-piece, of which so much use has been made in the classification of the *Aëdes* group by Dyar (1918) are developments at the apex and base of the lower flap of the side-piece. The terms are appropriate, and I do not propose to alter them, but it may be worth while to point out that the basal lobes of *Megarhinus* seem to be developed from the upper flap of the side-piece, and further that the basal lobes in *Uranotaenia, Theobaldia*, etc., which have the chitin of the side-pieces tubular, may not be homologous with the basal lobes of *Aëdes*. The ventrally-directed, *sub-apical lobes* of *Culex* seem to be an independent development, as they can be traced back to *Theobaldia*, where they originate as simple hairy knobs quite independent of the basal lobes. The latter have disappeared in *Culex*, the sub-apical lobes having probably taken on their function, whatever that may be.

In the *Aëdes* group a characteristic modification of the base of the *upper flap* of the side-piece occurs, which in the great majority of species has become practically a distinct organ. For this part the term *harpe* was used by Felt (1905), though that author had very imperfectly studied the homologies, and used the same term for the anal chitinisations of *Culex*. Howard, Dyar and Knab (1912) adopted Felt's terms in restricted and differing senses, and spoke of the parts now in question as *harpagones*. Both these terms, however, are unfortunate and misleading, especially the latter, which, as has already been stated, was originally applied by Buchanan White to the main clasping organs of the Lepidoptera, which are probably equivalent to the side-pieces. The name *harpe* was first introduced by P. H. Gosse (1883) for an internal appendage of the side-piece (harpago), and there would, therefore, seem to be some justification for the use Felt made of it in the Culicidae. However, I consider that the harpe of the Lepidoptera (in the sense of Gosse) is more likely to be the equivalent of the second joint of the forceps of Diptera, than of the special organs in

* It will be well to avoid the terms *dorsal* and *ventral* as far as possible to save possible confusion.

consideration which are only found in the genus *Aëdes*. Moreover, the term has been used so inconsistently in the Culicidae that its retention is undesirable without strong reason.

The term *claspette* was used in a loose way by Felt, apparently to cover any appendage, basal or apical, of the side-pieces, other than the clasper. Since the special organs of *Aëdes* are undoubtedly homologous with the basal lobes of some forms (if not of all), there can be no objection on morphological grounds to the use of the term *claspette* for them, and no confusion will result from its re-introduction, as it has not been in general use. I propose, therefore, to make use of it for the harpagones (Dyar) of *Aëdes*, and for the similarly derived structures of *Taeniorhynchus*, without necessarily intending to imply a strict homology between these two. The same name may also be applied to the parts in *Anopheles* which Christophers (1915) has spoken of as the harpagones, since it seems most probable that they are, as he suggests, homologous with the claspettes (harpagones) of *Aëdes*. The *claspette spines* of Christophers would be better known as the *basal spines*, since they are not borne by the claspettes and may well be homologous with the basal lobes of *Aëdes*. The term *basal lobes* I propose to reserve for the structures at the base of the lower flap of the side-piece in *Aëdes*, and for the hardly differentiated organs of some other genera (*Megarhinus*, *Theobaldia*, etc.).

Brolemann (1919 *b*) speaks of the claspettes as *gonapophyses*, and regards them as appendages of the tenth tergite, but this is merely owing to his fundamental misconception as to the anus and the genital opening. He has further been led to the erroneous deduction that the claspettes are primitive organs which have disappeared in *Culex* and other genera, whereas they are unquestionably special developments (most probably arising quite independently) in *Aëdes*, *Anopheles* and *Taeniorhynchus*. I prefer not to use the term *gonapophyses*, as it is a loose one used by different writers to indicate appendages of the ninth or tenth segment or of the genital tube.

Before leaving the side-pieces, it will be necessary to notice one other structure which has escaped the attention of most writers on the subject, Christophers excepted. This is an internal prolongation of the base of the side-piece on the lower (anal) side, variously

developed in different genera. I propose to term it simply the *apodeme*. Its importance will appear later on.

(*b*) *The second joint*. This I have spoken of as the clasper, and this term seems to be in fairly general use, though some writers, Christophers for example, have used it to include the basal joint or side-piece also. I do not think this fact need prevent its retention in the sense in which I have employed it. There has never been any doubt as to its homology throughout the Nematocera, unless perhaps in one or two aberrant species of *Aëdes*, but its modifications are extreme. On this account I object to the term *clasp filament*, which has been widely used by Howard, Dyar and Knab: the structure is only 'filamentous' in certain groups, the description being absurdly inapplicable to such elaborate developments as are found in *Sabethes*, and many *Aëdes*.

Berlese (1906) calls this part the *mesostylus*; Snodgrass (1904) the apical appendage, and de Meijere (1919) the *stylus*. The first two of these are not sufficiently expressive; no objection need be made to the third, but *clasper* seems to me preferable as having been in more general use by the English writers. In those Diptera (such as the majority of Limnobiinae and Mycetophilidae) where it is double it will be useful to speak of the *upper* and *lower claspers*, though it is possible that one part may have originally been a terminal joint, or a mere lobe of the other. This does not apply to mosquitoes. The position of the plane of articulation of the clasper is important. It is vertical, or nearly so, in *Culex*, almost horizontal in *Aëdes* (sub-genus *Ochlerotatus*).

The *spine* or *claw* of the clasper is best spoken of as such (*claw* being rather better than *spine*). It has been regarded by Brolemann (1919) as a third joint of the forceps, but this is not established. It may be *terminal* or *sub-terminal*, or rarely absent.

(3) The Anal Chitinisations. By most writers the anus of insects is regarded as opening at the tip of the tenth abdominal segment, though Berlese (1906) recognises an additional segment near the base, and so counts the anal segment as the eleventh, while Keilin (in conversation) considers the anus to be situated on an appendage of the ninth, and does not admit a separate anal segment. At present, I believe that the majority in this case are right, and I therefore propose to follow the usual custom and speak

of the plate or plates dorsal to the anus as the *tenth tergite* or *tergites*, and those ventral to it as the *tenth sternites*.

In many insects the tenth tergite bears a pair of appendages (the anal styles, stylets or cerci), but this is not the case in the males of any Culicidae. Both tergite and sternite, however, are generally divided completely into two parts. The *tenth tergites* have not, so far as I am aware, been noticed by any previous writer* on the family, though they are quite well developed as two simple plates in most of the genera, particularly in *Theobaldia* and *Culex*. Apically they are in contact with the tenth sternites, basally with the ninth tergite. Owing to the torsion, they, of course, occupy the most ventral position in the hypopygium.

The *tenth sternites* are conspicuous in most Culicidae, and are the parts miscalled *harpes* by Howard, Dyar and Knab and 'bras peniens' by Brolemann. Their true nature is shown in any lightly macerated specimen by the fact that the rectum is attached to them (and to the tenth tergites); furthermore, they nearly always bear some minute bristles, which illustrates their cuticular origin. Though this is not true of all other insects, bristles seem never to occur on the genital chitinisations of Diptera.

A condition of the anal segment very similar to what is found in the Culicidae occurs in the Cyclorrhapha. In *Glossina* the halves of the segment have been spoken of by Newstead (1911 *a*) as *superior claspers*, but the true homology of these parts has been pointed out by Awati (1915), whose opinion I can confirm. In *Phlebotomus*, however, Newstead (1911 *b*) calls the anal segment the sub-median *lamellae*, and uses the term *superior claspers* for the forceps. This is no doubt owing to his having overlooked the torsion, which is as regular a feature of *Phlebotomus* as of the Culicidae, and is one of the points of agreement indicating a connection between the two groups. In Mycetophilidae, Bibionidae and Cecidomyiidae the anal segment usually has a different form, the tergite being divided into two hairy lamellae resembling the cerci of the female, while the sternite remains entire.

The most primitive conditions of the anal segment is probably that in which both the tergite and sternite are simple. This is the case in *Chaoborus*, though here the tenth tergite is fused on to the ninth. A very similar condition occurs in the Lepidoptera (see

* They are indicated in some of my published figures, and also by Brolemann, but have not been specially mentioned.

below) and also in Chironominae. In *Anopheles* there is often practically no chitinisation either of tergite or sternite, the whole segment being membranous; in some species two ill-defined bars of chitin represent the sternite. The same is true of *Aëdomyia*, and in these cases Christophers' term *anal lobe* is appropriate.

In other Culicidae the form of the anal segment varies little, except in *Culex*, where the sternites develop crowns of spines and in many cases a strong *basal arm*, projecting upwards and more or less surrounding the aedoeagus. In their primitive condition (as regards the Culicidae) the tenth sternites probably bore apically a few strong bristles or teeth (as in *Theobaldia* and *Taeniorhynchus*); the number of these has greatly increased in *Culex* to form the crown of spines, while in *Aëdes* they have entirely disappeared. In addition to these spines there is nearly always a patch of a few very minute hairs, doubtless sensory in function, at the sides near the tip; these occur in *Aëdes* as well as in *Culex*. In all cases where they are well developed, the sternites have a downward projection in the form of a strip of chitin extending up to and articulating with the lobes of the ninth tergite (figured by Felt, 1905, p. 465). Whether this is a primitive or secondary structure I am unable to say. It does not appear to exhibit any characters which can be made use of in classification, and it will, therefore, be unnecessary to name it.

Dyar (1918) speaks of the anal sternites (harpes) as evolving from a simpler to a more highly developed form, and regards their absence in *Anopheles* as primitive. It is quite certain, however, that the reverse is true, and that this absence is due to degeneration.

(4) THE GENITAL CHITINISATIONS. As in the case of most other insects, the genital tube of mosquitoes opens between the ninth and tenth sternites, and its apical part, with one or more invaginations, is more or less heavily chitinised. These chitinisations have been called collectively by Felt (1905) and Howard, Dyar and Knab (1912) the *unci*, though in the case of *Culex* these writers have also spoken of parts of them as *harpagones*.

The inapplicability of the latter term has already been explained. The name *uncus* was first introduced by P. H. Gosse (1883) for the 'posterior part of the dorsal arch of the eighth segment' of the Lepidoptera, and has been in use ever since for the same structure,

which, however, was incorrectly described by Gosse as belonging to the eighth segment. It has since been homologised by Rothschild and Jordan (1904) as the tenth tergite. The term *unci*, therefore, ought not to be used for structures belonging to the genital tube. Brolemann's term 'cylindre perianal' is, of course, out of the question, being founded on a misconception.

Christophers (1915) and Awati (1915) have adopted the term *theca*, which was first introduced by Wesché (1906) for the 'penis sheath' of certain Diptera, chiefly Cyclorrhapha. I reject this, however, as it is not by any means in general use among students of other groups, and the homology of the pars in Cyclorrhapha is still very uncertain. The alternative term *adminiculum* of Westhoff (1882) has not often been adopted. The whole structure is often spoken of, perhaps correctly, as the *penis*, but I consider that this term would be better reserved for the actual intromittent organ when present. On the whole the term which seems open to the least objection for the chitinised parts of the genital tube is *aedoeagus*, which, according to Sharp and Muir (1912) was introduced by Foudras in 1859. It is in general use among Coleopterists in the sense indicated, but, unfortunately, has been employed by Pierce (1914) and other Lepidopterists in a much more restricted sense, to indicate the intromittent organ. I consider that Sharp's usage is the one that should be followed, and propose to adopt the name *aedoeagus* for the *ensemble* of chitinous structures of the genital tube of Diptera, thus exactly reversing Pierce's use of the terms penis and aedoeagus.

The apparent correspondence between primitive Diptera and primitive Coleoptera in the details of structure of the aedoeagus is remarkable, and comparable modifications have also been described for the Anoplura and Mallophaga. There is, of course, an immense divergence between the more specialised species, but in the more primitive forms, among which may be included the majority of the Culicidae, it is possible to distinguish the following parts:—

(*a*) *Basal plates*. These are a pair of chitinisations of the sides of the genital tube lying within the ninth segment and often extending back into the eighth. They doubtless serve for the attachment of muscles. Although generally overlooked, they have been mentioned by Dyar (1918) as *ligaments* and by Brolemann

(1919 *b*) as *apodèmes aliformes*. The name *basalplatte* was proposed by Verhoeff (1893) for the corresponding structure in the Coleoptera, where, however, it usually forms but a single piece. I propose to adopt this name, using it in the plural, as the structures are apparently always paired in the Culicidae. Sharp and Muir (1912) prefer the expression *basal piece*. Waterston (1914) and Cummings (1916), on the other hand, use basal plate.

The basal plates vary much in size, attaining their maximum in *Culex* and *Theobaldia*. They articulate near their inner extremities with the apodeme of the side-piece, and it is noteworthy that the size of the apodemes varies inversely with that of the basal plates. In very many cases (conspicuously in *Theobaldia longiareolata*) there is a definite fusion between the basal plate and the apodeme, so that it is impossible to say where one ends and the other begins. In *Uranotaenia* this fusion is for almost their entire length. At their outer ends they articulate in a notch situated near the middle of the parameres, and they are also in close contact, though never fused, with the tenth sternites.

(*b*) *Parameres*. These are paired structures which, as just mentioned, articulate with the basal plates. They are nearly always present, though in varying degrees of development, being very minute in *Aëdomyia*, and perhaps absent in *Anopheles*. They were formerly referred to by Dyar and Knab (1909) (in *Culex*) as the fourth plate of the harpagones; more recently by Dyar (1918) as the first uncal plate. Brolemann (1919 *b*) calls them *trigonapophyses*. Berlese (1906), Snodgrass (1904) and de Meijere (1919) use the term *gonapophyses*.

The term *parameres*, which I have adopted as most suitable, was proposed by Verhoeff (1893) for the Coleoptera, and has been adopted by Waterston (1914) and Cummings (1916) for the Siphonaptera and Mallophaga respectively. While in these different orders the structures may not be strictly homologous, they are certainly similar in position and appearance. Sharp and Muir (1912) prefer the expression *lateral lobes*.

In some cases, though not in any mosquitoes, the parameres are fused with one another and with the basal plates. When this is so, Sharp's term *tegmen* may aptly be applied to the whole structure. This seems to be the condition in the genus *Molophilus*.

(*c*) *Mesosome.* Lying between the parameres is a more or less complicated body which has been incorrectly styled the *unci* by Howard, Dyar and Knab (1912), or the second, third and fourth uncal plates by Dyar (1915). Though apparently composed, especially in *Culex*, of one or more pairs of distinct organs, a close examination will nearly always show that it is really only one piece, more or less elaborately lobed. The very handy term *mesosome* was proposed by Waterston (1914) for the structures lying between and distal to the parameres of the Philopteridae (Mallophaga), and I propose to make use of it. I think it is preferable to the *median lobe* of Sharp and Muir (1912) since the structure often bears many lobes or divisions.

The mesosome is a thickening of the walls of the distal part of the aedoeagus. The chitin seems generally to be disconnected on the upper (apparent dorsal) side, but the lateral portions are generally, if not always, connected by a chitinous *bridge* (a good term used already by Dyar) on the side nearest the anus. This bridge varies much in width in different species, being extremely broad in *Aëdes* subgenus *Ochlerotatus*, and very narrow in many species of *Culex*. When the halves of the mesosome are connected by chitin on the dorsal and ventral sides of the genital tube, the bridge nearest the rectum may be called the *lower bridge*, and that furthest from it the *upper bridge*. The terms dorsal and ventral would be ambiguous, and had best not be used. The two bridges are both distinct, though narrow, in *Culex*. In the higher members of this genus there are two or more fairly distinct parts of the mesosome, which seem to be developed mainly or entirely on the upper wall of the tube, and probably do not indicate an invagination of the tube. When a second invagination is present* the terms *endomere* and *telomere* have been used by Waterston (1914) and Cummings (1916) for the proximal and distal portions of the mesosome. I have not been able to satisfy myself, however, that any such division occurs in the Culicidae, even among the more complicated forms.

The structure of the mesosome is of great taxonomic importance, and there is probably no other single organ of the body which gives better clues to the true phylo-genetic relationships of the species.

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* The first is at the base of the parameres.

It is beyond the intention of this paper to discuss its modifications in detail, but it may be mentioned that in *Culex* the bridge or bridges are nearly or quite basal, the part beyond them being drawn out into horns or spines, usually on the upper side of the tube. In *Aëdes*, on the other hand, as in many other genera, the lower bridge is almost or quite apical; as it is also much broader, the mesosome of these forms is necessarily practically a rigid structure, and is only capable of slight extension by the action of the parameres, conjunction with the female being effected mainly by the aid of the mobile forceps. In *Megarhinus* the lower bridge occupies a middle position, and in this as in some other points this genus should probably be considered among the most primitive of the family.

The true genital structures of *Anopheles* are very different from those of other Culicidae, and are difficult to homologise. It is almost impossible to distinguish parameres, basal plates and mesosome as can be done in the other genera of the family. The first two appear to be represented by a small single piece no larger than the paramere of *Aëdomyia* (see fig. 2, *c*). The mesosome is Christophers' *theca*, but it is of a very different form from that of any of the other genera. A very careful study of cleared and floating specimens of some of the more generalised *Anopheles*, such as *A. plumbeus* or *A. argyrotarsis*, shows that it approaches nearest to the simple form seen in *Ochlerotatus*, with a very broad lower bridge. In most species, however, the chitin has become definitely tubular and the remarkable and characteristic *leaflets* have been developed at the tip.

The structure of *Chaoborus* is also very different from that of the Culicinae, and here there would seem to be no definite aedoeagus. There is only one pair of chitinous organs at the base of the side-pieces, occupying a vertical position and possibly to be regarded as developments of the side-pieces themselves. A similar condition occurs in the Chironomidae (excepting Ceratopogoninae), and in both cases is most probably retrogressive. It is possible that a connection may be indicated between the Culicidae and Chironomidae through *Chaoborus*, which, indeed, would also seem likely from a study of some other organs.

Hardly anything is yet known as to the precise function of the different parts of the hypopygium, but one point which is clear from

a study of macerated specimens of *Culex* may be mentioned, as it is of some general interest. The parts of the aedoeagus (see Edwards (1914)) are observed in microscopic preparations in two different positions relative to one another. In one, the position of rest, the halves of the mesosome lie close together, project tailwards, and are partly covered by the parameres. In the other, probably the position of use, the parameres are folded back and the halves of the mesosome either divaricated from the bridge outwards or bent downwards on to the anal sternites. A comparison of specimens in these two positions (the examination should be made in clove oil under a binocular microscope) will show that in the first the upper bridge of the mesosome lies proximally to the lower, and both are almost in the line of the longitudinal axis of the body, the aperture of the genital tube thus being closed. The folding back of the parameres has the effect of pulling back the upper bridge of the mesosome, so that it and the lower bridge lie in a plane vertical to the body, and at the same time divaricating the halves of the mesosome (which lie distal to the bridges and are not connected by membrane), and turning them downwards. The result is not only the genital tube is opened, but that the lower bridge, or the whole mesosome presses on the tenth sternites and thus closes the anus, probably at the same time transmitting some stimulus by touching the minute sense-hairs on the tenth sternites. A quite analogous condition has been described by Waterston (1909) in the Siphonaptera, but I have not seen anything approaching it in other genera of mosquitoes.

The accompanying diagram (fig. 1) will help to explain the

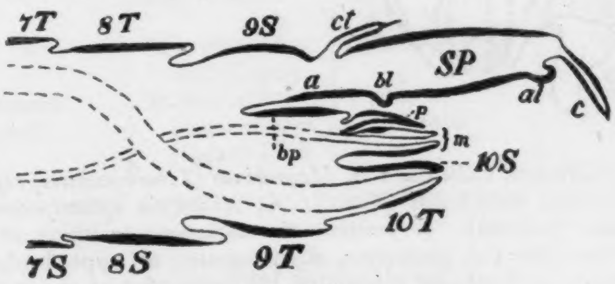

FIG. 1

Ideal section through tip of abdomen of an *Aëdes*. The thick lines represent chitinisations, the thin ones membrane. Note the wide membrane between the 8th and 9th segments, which allows of the torsion *7T*—*10T*, seventh to tenth tergites: *7S*—*10S*, seventh to tenth sternites; *SP*, side piece; *c*, clasper; *ct*, claspette; *bl*, basal lobe; *al*, apical lobe; *a*, apodeme; *bp*, basal plate; *p*, paramere; *m*, mesosome.

foregoing analysis of the Culicid hypopygium. It represents an ideal longitudinal section through the tip of the abdomen of an *Aëdes*, this type being chosen as offering the maximum development of all the structures. All the parts shown are, of course, not actually in the same vertical plane, and the claspettes and parameres are shown dorsal to their true position for the sake of clearness. The course of the rectum and ejaculatory duct is indicated by dotted lines, since it is not quite certain what happens to the internal organs after the torsion. If this diagram be compared with one given by Cummings (1916, p. 688) for the Mallophaga, it will be evident at once that there is a striking similarity in many respects. Camera lucida drawings are also given of the aedoeagus of *Megarhinus*, *Ochlerotatus*, *Aëdomyia* and *Theobaldia* (fig 2, A-D), in order to show the principal types of mesosome.

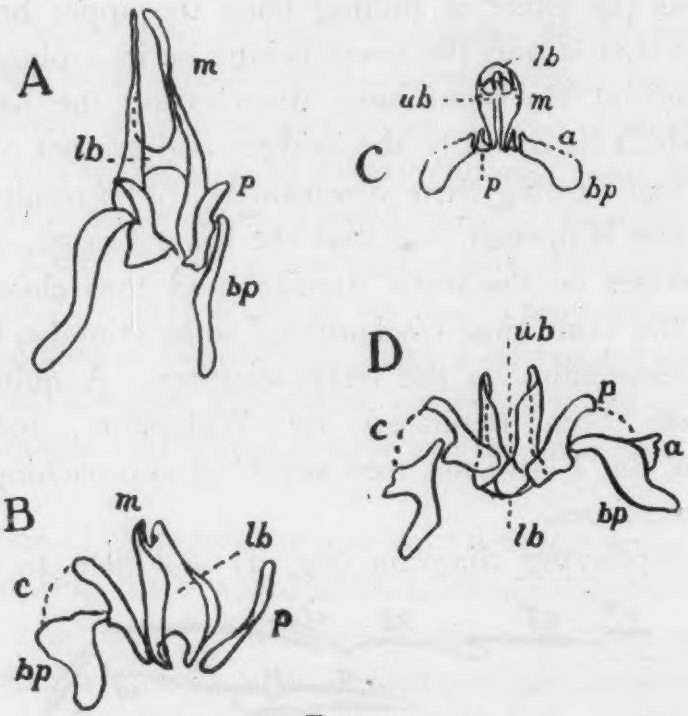

FIG. 2

Aedoeagus of different Culicidae: A, *Megarhinus* (*Toxorhynchites*) *regius* (Tennent); B, *Aedes* (*Ochlerotatus*) *waterhousei* (Theo.); C, *Aëdomyia squamipennis* (Arrib.); D, *Theobaldia annulata* (Schrank). *a*. position of attachment or fusion of apodeme with basal plate; *bp*, basal plate; *p*, paramere; *m*, mesosome *ub*, upper bridge, and *lb*, lower bridge of mesosome; *c*, membrane connecting the outer edge of the paramere with the basal plate.

To sum up, a table is also given shewing the chief terms which have been used by different writers on the Culicidae, and for comparison, the equivalent terms used by Newstead (1911 *b*) for

Phlebotomus and by de Meijere (1919) for the *Tipulidae*. The last-named author compares his nomenclature with that of Berlese, Snodgrass and Westhoff, so that it will be unnecessary to add their terms to this table; reference may be made to de Meijere's work.

In conclusion, I wish to express my indebtedness to Dr. D. Sharp and Capt. J. Waterston for much kind assistance on difficult points.

Proposed Terms	Felt, 1905	Dyar, 1918	Brolemann, 1919	Newstead, 1911	de Meijere, 1919
Ninth tergite ...	Setaceous lobes	Basal appendages	Ninth sternite	Inferior claspers	Ninth tergite
Ninth sternite ...	—	—	Ninth tergite	—	Ninth sternite (proximal part)
Side piece ...	Basal joint of clasp	Side piece	First joint of forceps	Superior clasper (basal joint)	Basal joint of forceps (part of ninth sternite)
Basal lobes ...	Claspette	Basal lobes	Verrue basale	—	—
Apical lobes ...	Claspette	Apical lobes	Saillie apicale	—	—
Claspettes ...	Harpes	Harpagones	Gonapophyses of 10th sternite	Intermediate appendages	—
Apodeme ...	—	—	—	—	—
Clasper	Second joint of clasp	Clasp filament	Second joint of forceps	Superior clasper (second joint)	Stylus (terminal joint of forceps)
Tenth tergites ...	—	—	—	Submedian lamellae	Tenth tergite
Tenth sternites ...	Harpes (*Culex*) Harpagones (*Aëdes*)	Harpes	Bras penien		Tenth sternite
Aedoeagus ...	Unci ?	Unci	—	—	—
Basal plates ...	—	Ligament	Apodème aliforme	Intromittent organ	—
Parameres ...	—	First plate of unci (*Culex*)	Trigonopophyses		Gonapophyses
Mesosome ...	Harpagones (*Culex*)	Second to fourth plates of unci (*Culex*) Unci	Cylindre perianale	Genital filament	Penis

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STUDIES ON THE VARIOUS TYPES OF MALARIAL INFECTION AND THE EFFECT OF QUININE TREATMENT THEREON AMONG THE NATIVE POPULATION OF THE MALAY ARCHIPELAGO

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I. INTRODUCTION

During the course of our researches on malaria in the malarial districts of the Malay Archipelago, we have examined the blood of numerous natives, including those who were being subjected to quinine treatment. We were induced to do so on the following grounds:—Our primary object was to ascertain the percentage of different species of Anophelines showing malarial infection in nature, and we soon found that no comparison could be made between the results obtained in different localities without having some definite notion regarding the number of gamete carriers in each district.

The result of blood examination in various localities revealed, however, some facts which seemed worthy of record, particularly in their bearing on quininisation and its effects.

In the following pages we will give a short account firstly of malaria in the Malay Archipelago, secondly of the types of malarial infection found by blood and spleen examinations, and thirdly of the changes observed in these types by quinine treatment.

II. MALARIA IN THE MALAY ARCHIPELAGO

There are numerous places where malaria is endemic, *e.g.*, in many parts of the north coast of Java, where the spleen rate is continuously high, but the morbidity (as expressed by the admissions to the hospitals) shows considerable fluctuations. In Semarang, in 1917, the rate of admission was very high, and in 1918 it sank almost to zero. Still this does not indicate that the malarial infection was a low one, examination of the native population disclosing a spleen rate of 80 to 90 per cent., and a parasite rate of 24 to 38 per cent. in children. This shows how little value can be attached to the admission rate as a measurement of malaria. Still this rate is an indicator of some sort, and when in one year there are more admissions than in another, we may assume that the frequency of malaria has been altered likewise.

Not only is there a fluctuation in the amount of malaria from one year to another, but, as in other countries, this fluctuation is seasonal, and it is a striking feature that most cases occur (and usually the mortality is at its height) in July-August, during the dry season (Chart 1).*

This rule generally holds, but there are exceptions. As an instance, we found a severe epidemic in Kepetakan (north coast of Java) in May and June (beginning of the dry season), and one in Soendatar (Sumatra) in April and May (end of the wet season).

Although there may be many transitional forms, we may distinguish: (1) *Endemic malaria*, maintaining a high spleen-rate all the year round, showing each year an exacerbation in the periods mentioned above, and especially severe exacerbations in periods separated by an interval of a varying number of years. (2) *Epidemic malaria, i.e.*, periodical severe outbreaks in districts where, as a rule, this disease is rare.

* This is a well-known fact in our colonies. We emphasize it, because it is usual to cite Koch's report (1900), when referring to malaria in the Dutch East Indies. This report states that in these regions malaria is most frequent at the beginning and the end of the dry season (October to November, April to May). This erroneous statement led Koch to the conclusion that malaria was not frequent in Batavia, because in the off-season (October to November), which was supposed by him to be the malarial season (beginning of the wet monsoon), he found only a comparatively small number of cases. This conclusion in its turn made him praise the Government for their gratuitous quinine distribution among natives, which, according to Koch, had caused the marked reduction of malaria.

The general tendency of the outbreaks to occur in the dry season, is a feature especially noticeable along the north coast of Java, but also to be observed in the interior. Probably this tendency has various causes, but one at least we have been able to elucidate, viz., the periodicity of the Anophelines.

Along the coast in Java and Sumatra, *M. ludlowi* has been shown by us (1918, 1919) to be the principal carrier. It breeds, together with *M rossi*, in the salt-water ponds along the coast, overgrown with algae (*Enteromorpha, Cladophora*) and other filamentous weeds (*e.g.*, *Najas* sp.). These pools contain a mixture of fresh and salt water and, as the dry season proceeds, they become more and more brackish, as has been shown by v. Breemen (1919). In June to August, these pools are excellent breeding-places for *M. ludlowi* and *M. rossi*, which occur there in enormous numbers, hundreds of larvae being gathered at one dip. But at the end of the dry season (September, October, sometimes as early as August) the larvae disappear completely, as we have noted in Tegal, or only *M. rossi* remains, as was the case in Semarang. V. Breemen has shown that this occurs when the salinity of the water exceeds a certain amount of NaCl. The malarial frequency is much reduced, shortly after *M. ludlowi* becomes scanty or disappears.

In the interior *M. ludlowi* is usually absent (except in some parts of Sumatra, *e.g.*, Mandailing, where this mosquito exists all the year round, although in somewhat varying numbers) and the principal carrier there is *M. aconita* (sometimes *N. maculatus* or *N. leucosphyra*). Except in very small islands, there is always plenty of water at the disposal of the larvae, and so it is not clear why *M. aconita* (in a station which we observed for almost a whole year) should not breed permanently, as its larvae were found in the rice-fields, which are inundated from January till July and from August till November. The fact is, that it was only observed in great numbers (as larvae and adults) during the height of the dry season (June, July) at the time of the cutting of the first crop of paddy; the conditions prevailing in mature rice-fields, ready to be harvested were, in this instance, particularly favourable for the breeding of this species.

III. THE TYPES OF MALARIAL INFECTION AMONG THE POPULATION IN THE MALARIAL DISTRICTS

Before describing these types, it will be useful to explain some terms used here. We distinguish between the 'infection-rate' and the 'parasite-rate.'

The infection-rate is :—

$$\frac{\text{number of tertian} + \text{quartan} + \text{subtertian-infections}}{\text{number of persons examined}} \times 100$$

The parasite-rate is :—

$$\frac{\text{number of parasite-carriers}}{\text{number of persons examined}} \times 100$$

The first rate may be greater than the second if mixed infections are present (Table XVIII). It may also surpass 100 per cent.

1. *The endemic type*

This type occurs in localities of high and continuous endemicity. The spleen rate is high in children and remains so in adults (Table I

and Chart 2). This fact,* first recorded by Schüffner (1919) is remarkable, as it is generally asserted that the spleen rate should be taken in children under ten years of age; the splenic enlargement rapidly decreasing in adults.

The infection rate, on the other hand, shows the well-known reduction in older children and in adults. It reaches its maximum in the 4-5 year period, and always remains much below the spleen rate. The decrease of the three species of parasites does not proceed with the same rapidity, simple tertian and quartan usually disappearing sooner than subtertian, and the crescents sooner than the subtertian asexual forms (trophozoites). This latter fact causes the ratio of the number of crescent carriers to the total number of subtertian cases (referred to in the following pages as $\frac{c}{t}$) to diminish (Table I and Chart 2).

Darling (1911) showed that 1 crescent per 500 leucocytes in the blood is the smallest number capable of infecting Anophelines. We use the term 'highly infective' carriers for those showing 1 or more crescents per 100 leucocytes. These highly infective carriers are more numerous among children than among adults in endemic regions (Tables I, V and XIV and Charts 2 and 4).

Mixed infections occur both in adults and children, but in the latter they are more numerous. In adults they may even be absent (Table XVIII).

There is a certain amount of confusion regarding the part played by immunity in the production of gametes. On the one hand, all observers agree that in endemic regions the children are heavily infected, the adults very slightly so or not at all. Here immunity causes the disappearance of all parasites and consequently, of the gametes also. On the other hand Koch (1900) states that incipient immunity causes a condition, named by him 'latent malaria,' in which morbid symptoms are absent, but parasites, and especially sexual forms, are still present. This condition is found in elder children and adult immigrants, who have already suffered from numerous relapses and reinfections. Sergent (1910) also mentions a similar state found in Algerian natives under similar conditions.

Thomson (1911) asserts that crescents are produced after the development of partial immunity. He bases this statement on the following facts (among others):

(1) The ratio $\frac{\text{crescents}}{\text{trophozoites}}$ rises when the asexual forms diminish in number.

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* We observed it everywhere in Java and Sumatra and also in many isolated localities, in the eastern portion of the Archipelago (even in New Guinea, Table XVII), in every way corresponding to the villages of Bongu and Bogajim, studied by Koch (1900), where the spleen rate at the age of 14 and over sank to zero.

(2) The number of crescents rises with the duration of the malarial infection, with the degree of splenic enlargement and with the age of the patient (if he has been constantly or frequently exposed to malarial infection).

It would thus seem that incipient immunity stimulates the production of gametes and that, consequently, they are more numerous in elder children. Our observations tend to show that in the Malay Archipelago the presence of crescents indicates the absence of immunity, as they are most numerous in younger children, decreasing in number with age, even more quickly than the trophozoites. The fact that the number of crescent-carriers arranged according to the degree of splenic enlargement rises and falls simultaneously with the rise and fall of the number of carriers of trophozoites (Table II) corroborates this view.

On the other hand we noted an inverse relation, between the numbers of trophozoites and crescents, in persons suffering from subtertian malaria (Table III). This fact, of course, would seem to support the view, that the formation of crescents is a reaction against the immune-bodies. The fact of the steady rise of the number of crescent carriers and of the value of $\frac{c}{t}$ from the beginning of the epidemic of Modjodjedjer through four successive months (Table XIII, Chart 12) gives this an additional support.

We therefore conclude that if the production of crescents is at all stimulated by immunity, then it should be regarded as a very early symptom of the formation of antibodies, becoming manifest at a time when no other symptoms (fall of infection and spleen rate) are perceptible, and disappearing with the appearance of these latter symptoms. The cases of latent malaria (no morbid symptoms, with parasites still present) are either not crescent carriers at all or the crescents are present in negligible numbers only.

Adult emigrants from healthy regions, coming into endemic districts, show numerous crescents in their blood, just like children. These newcomers certainly form an additional danger to the community. We observed this by examining mosquitoes (*M. ludlowi*) in the house of one of them. Out of ten *M. ludlowi* caught there, seven were found to be infected; out of two hundred and twenty-nine *M. ludlowi* caught in the surrounding (native) houses of the same village, nineteen only showed infection. In another similar case, four *M. ludlowi* out of one hundred and one were found infected in the native village, and four out of six in the house of a European family, where two of five children harboured crescents in the blood (one crescent to ten leucocytes).

Exceptions to the rule

In Tandjong Pinang (Riouw Archipelago), a notorious malarious small town, as has been proved by the examination made by various medical officers, we found aberrant conditions. Judging by the distribution of subtertian, we had here a purely endemic type, as was

to be expected. But mixed infections (Table XVIII), tertian and quartan, were so numerous among adults as to resemble the epidemic type. The medical officer, Dr. Poser, who was in the habit of making blood films of every case of fever coming under his notice, informed us that in 1917 (the year preceding our survey) he found on an average sixty-five subtertian cases to thirty tertian and five quartan cases. We found this ratio to be 63 : 40 : 40. We conclude that the conditions for the spread of tertian and quartan had become much more favourable of late, among a population heavily infected with subtertian but not so with the other species, and consequently not immune against them. Of course, this explanation can only be accepted if we admit Koch's statement that immunity against one species of malaria parasite does not confer immunity against the others (Chart 3, Table IV). In Penjengat, another island of this Archipelago, we found similar conditions. Here another point is to be noted, viz., the low spleen rate of the adults. This is easily explained by the fact that the men mostly lived by fishing and went out to sea each night from 5.30 p.m. till 8.30 a.m. of the next day, many of them being in this way protected from infection, but at the same time prevented from maintaining their immunity (Chart 3, Table IV).

The most notable feature of the endemic type is the reduction of the crescent rate and of $\frac{c}{t}$ in adults. How is the latter to be explained? It may be due to the fact of immunity diminishing the power of the subtertian parasites to produce gametes, without killing the trophozoites. But it may be, also, that the number of trophozoite carriers is kept up to a certain level by continuous reinfection, but that the rings are being constantly killed, not so quickly as to remain imperceptible to microscopic examination but too quickly to produce gametes.

2. *The sub-endemic type*

Regions with high and continuous endemicity are often surrounded by others of less, but still continuous, endemicity, provided that the breeding-places of the transmitting *Anopheles* are not spread evenly over the whole country, but are localised. Such conditions exist everywhere on Java's north coast. Villages or

those quarters of towns which adjoin the salt-water marshes or salt-water fishponds, where *M. ludlowi* breeds, are highly malarious, but villages or quarters situated behind this zone are less so. Occasionally, however, there are severe outbreaks even there (partly at least caused by *M. ludlowi* penetrating farther inland than is its wont, as has been shown to be the case in Tegal and Semarang). When such outbreaks occur, a condition is realised somewhat intermediate between the epidemic and endemic type (Chart 4, Table V). The infection rate in adults is still much below that in children, but the tertian and crescent rates are comparatively high:— $\frac{c}{t}$ is equal in adults and children, so is the rate of infective crescent carriers. Usually the spleen rate is 30 to 50 per cent. in children and adults, 20 per cent. towards the periphery of the region. The infection rate is reduced correspondingly, but it is a curious fact, that the chart of blood examination arranged according to age (Charts 5 and 6, Tables VI and VII) shows the same features as in regions of high endemicity, *i.e.*, highest rate of infection in young children and very low one in adults. The decrease of the crescents in adults is likewise noticeable, but $\frac{c}{t}$ and the rate of infective carriers is not lower than in children. In Chart 5 we note a sudden rise in the infection, crescent and spleen rate at the age of 16 to 20. This is to be explained by the fact of the immigration of young coolies from non- or slightly malarious districts.

In comparing Chart 6 with Charts 2 and 5, we note another feature worth recording. In the regions of highest endemicity of Semarang (I, II, III) the infection rate reaches its maximum at the age of 4 to 5. In districts of lowest endemicity (IV) this maximum is reached at the age of 6 to 7. The lower rate of infection among the youngest children might be explained by the supposition that they are less exposed to infection than the older ones (personally, we believe this not to be correct). But this reason does not hold for children aged 4 to 5. Here another explanation is to be looked for, which may be found in the smaller chance of becoming infected. In the districts I to III, this chance is so great that the majority of children who become at all infected have contracted the disease one or more times before the expiration of the fifth year. But in district IV, this chance is much reduced, in consequence of which

it takes a greater number of years to reach the maximum infection rate.

3. *The epidemic type*

This is the type we met when an outbreak of malaria occurred in a place where the disease was said to be previously absent. Only once (at Modjodjedjer) we were able by personal examination to verify this statement.

The spleen rate of children and adults does not differ materially. It may be as high as or lower than that in endemic regions. In comparison with the spleen rate, the infection rate is much higher than in the latter areas, being equal to or surpassing the spleen rate. In consequence of this fact, the percentage of parasite carriers with non-enlarged spleens is much increased, especially at the beginning of an epidemic; later on the equilibrium is re-established (if no quinine is administered, *v. infra*) (Chart 14). There is no marked and constant difference in the composition of the parasite-fauna in the blood of persons of different age; the crescents are nearly as numerous in adults as in children, the rate of infective carriers differs slightly only, likewise the value of $\frac{c}{t}$. Contrary to the conditions prevailing in endemic regions, not only the children but the adults also are gamete reservoirs, in consequence of which the total number of infective carriers is much greater. This means for the Anophelines a greater chance of becoming infected. As an instance we mention that in endemic regions we found 3 to 4 per cent. of *M. ludlowi* infected in nature, whereas in epidemic regions the rate of infection was 16 to 35 per cent. An insignificant carrier like *M. rossi* showed a rate of infection of 0·3 to 0·4 per cent. in endemic regions, and one of 3 per cent. in an epidemic district (Charts 7, 8 and 9, Tables VIII, IX and X).

IV. CHANGES OBSERVED IN THE TYPE OF MALARIAL INFECTION UNDER THE INFLUENCE OF QUININE TREATMENT

It is generally supposed that quinine treatment among a population retards immunisation. This, at least, is Koch's opinion, who endeavours to explain away the difficulties opposed to his theory of immunity, by the effects of quininisation (1900). Another of these

effects is stated by Ross (1910) to consist in the reduction of the splenic enlargement without an accompanying disappearance of the parasites. As a third effect, James (1910) states that he has observed a rise in the number of crescent carriers.

As the results of a malarial survey are largely based on the blood and spleen examination, and as the facts mentioned seem to indicate that quinine treatment may modify to a considerable extent the value of the infection and spleen rate, we have endeavoured to elucidate the changes which occur in both indices in the course of a wholesale quininisation among a population, such as is usually performed only in times of severe epidemics. Our object in doing so was merely to prevent errors which might result from our ignorance as to the effect of this treatment.

We have observed this effect in three epidemics, where we had determined the infection and spleen rate previous to the commencement of the treatment. We will here deal with them separately.

1. *Epidemic in North Soendatar*

Data referring to the conditions before and after the treatment are given in Charts 10 and 14, and Tables XI, XV and XVI.

The campaign lasted for one month only. Quinine was given in cases of fever only, in the following doses, for one week at a time:—

Total population: 1264

0–2	years	0·2	grammes quinine-sulphate, p.d.		9	cases.
3–5	„	0·4	„	„ „	194	„
6–12	„	0·6	„	„ „	185	„
13–18	„	0·8	„	„ „	106	„
19-	„	1·0	„	„ „	379	„

Individual treatment was continued for one week at least; for more if fever reappeared. Prolonged treatment may be enforced, but renders the whole proceeding highly unpopular, for which reason it is not encouraged by the authorities, and we had to do without it.

The changes in the spleen and infection rate after a month are insignificant. The spleen rate remains almost the same in children, but it is distinctly reduced in adults. The infection rate is reduced in both, but especially in adults. This is due to the

fall of the quartan infections, less so to the reduction of the tertian and subtertian infections. The crescent rate has been diminished slightly in children, more so in adults. The value of $\frac{c}{t}$ which, before treatment, was higher in adults than in children, has been reduced in the former. The rate of highly infective carriers has been decreased only slightly in adults and children (Table XVI).

The epidemic existed already for some months before the time of our survey and had attained a stationary condition. An equilibrium had been established between the spleen and parasite rates, *i.e.*, there were only a few parasite carriers without splenic enlargement. After the treatment, the percentage of parasite carriers not showing any palpable splenic enlargement had risen; more so in adults than in children (Chart 14, Table XI).

The fact that all the changes observed after the treatment are more marked in adults than in children may be ascribed to the fact that the first took more quinine.* It remains to be noted that, although there is no marked change in the splenic enlargement, the average enlargement has been much reduced (Table XV). Mixed infections, numerous in adults and children before the treatment, have decreased in number, especially in adults (Table XVIII).

In this and the following examples we compare the results of examination before and after treatment, without selecting the individuals known to have taken quinine. This was done in the cases of one hundred and five children and ninety adults (Chart 10*a* and Table XI*a*), but we did not observe any marked difference. From this we infer that the majority of fever patients really took quinine. This is satisfactory, but it should be remembered that in this and the other examples (except Margaredjo, *v. infra*) we have to do with epidemic malaria. The population is not used to it, is thoroughly frightened and glad for any help offered them. Blood and spleen examinations are no longer a favour they grant, but a succour which they gladly accept, believing it to be a peculiar form of preliminary treatment, which renders quinine more effective.

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* But it may also be due to the nature of malarial infection in children rendering its treatment more difficult. The fact that it was so little effective in 105 children whom we knew to have taken quinine, seems to support this supposition. The experience at Margaredjo (v. infra) on the other hand, shows that children are not resistant to treatment.

2. *Epidemic of South Soendatar*

Conditions before and after treatment are noted in Charts 11 and 14, and Tables XII, XV and XVI. Method and period of quininisation are the same as in the preceding paragraph.

Circumstances were somewhat different from those existing in North Soendatar, because the epidemic was still on the increase during the treatment. In consequence of this, conditions were worse after the treatment than before. In children and adults the spleen and infection rates have risen, but tertian and quartan infections have been much reduced in adults, the increase of the infection rate as a whole being due to the subtertian infections. The crescent rate has risen in children and fallen in adults, the value of $\frac{c}{t}$ has been reduced in both, but especially in adults. This also holds for the rate of infective crescent cases. Mixed infections have decreased in both, but more markedly in adults (Table XVIII). The percentage of parasite carriers without enlarged spleen was already high before the treatment, and equal in adults and children. After treatment it has increased in both, but more in adults than in children. The reduction of the average splenic enlargement is well marked (although less so than in North Soendatar). This is remarkable, as the spleen rate has increased.

3. *Epidemic in Modjodjedjer*

(Charts 12 and 14; Tables XIII, XV and XVI.)

Quininisation was effected here (*a*) by house to house distribution, (*b*) by distribution at the missionary hospital clinic. The first was continued for about four weeks, the second for the whole time of the epidemic (June to September). As the natives there are used to European medication, even this method ensures a considerable use of quinine, but more among adults than among children. The dose for adults was 1·2 grammes of quinine sulphate p.d., for children 0·2 to 1·0 grammes. Two hundred and ninety of a population of six hundred and forty were treated.

Results were somewhat complicated by an outbreak of quartan malaria that appeared towards the end but which was absent at the beginning of the treatment, a fact offering a certain analogy to the

observations made in the Riouw Archipelago (cf. pages 57, 66). Moreover, the examination before the treatment was performed at a time when the epidemic was still increasing in severity, whereas the last examination occurred after the epidemic had reached its maximum.

The spleen rate in children and adults, almost equal at the onset, have both been altered, the first being increased and the second reduced. The crescent rate before the treatment was highest in adults. Afterwards it rose in children, in adults it almost sank to zero. Similar changes occurred in the tertian rate, whereas quartan became more numerous in adults than in children. The subtertian rate sank in both, but especially in the former. The value of $\frac{c}{t}$, which at first was equal in adults and children, afterwards rose in the latter and decreased in the former. The rate of highly infective crescent carriers remained stationary in children, but was much reduced in adults. During the time of our first examination, there still existed in adults and children numerous parasite carriers not showing splenic enlargement, the epidemic being at its commencement. After the epidemic had existed for about three months, the equilibrium was almost reached in children, only a small percentage of parasite carriers not suffering from splenic enlargement. But in adults this percentage was even higher than at the beginning. The average enlargement of the spleen has increased, even in adults, although the spleen rate has been reduced. We believe this to be explained by the fact that the average splenic enlargement is highest in quartan infections, and these occurred at the end of the epidemic (Table II).

Endemic malaria in Margaredjo

(Charts 13 and 14; Tables XIV and XVI.)

Judging by the former experiments, it might be inferred that a more or less considerable amelioration may be attained in adults, but that in children success is hardly perceptible. This is true if the treatment lasts for a comparatively short period only, but the quininisation of school children in Margaredjo shows that even in children results may be obtained.

The regular treatment of every child in the missionary school

has been continued by Dr. Bervoets for more than ten years. The successive generations of children have been trained so effectively that they come for treatment at each illness. When this proves to be malaria they undergo a complete cure for three weeks, and an after-cure for the time necessary to free them from excessive splenic enlargement and anaemia. The latter cure includes not only quinine but also iron preparations.

In conditions relating to malaria, Margaredjo resembles Samarang I-III. It is situated near the *ludlowi*-breeding salt-water marshes and fishponds. The spleen rate of the young children equals that of Semarang I-III. But at the time of our visit the infection and crescent rates of these children were much higher.

We divide the school children into three classes:—(1) Those which have been in the school and under treatment for one and a half to two years (aged 6-9); (2) for three to four years (aged 10-11); (3) for five to seven years (aged 12-13).

Under this régime infection and spleen rates diminish; at first tertian, quartan and crescents only, later on subtertian, which is the only, much reduced, infection still existing in the oldest class.

These changes, well marked by themselves, appear more striking when comparing the results of the examination of children in Margaredjo and Semarang (Chart 13). In both the infection rate gradually diminishes, but its composition is quite different. In Semarang there remains tertian infection (not to mention quartan, which in Margaredjo was scarce from the onset) and numerous crescent carriers, giving a high value to $\frac{c}{t}$. In Magaredjo we note a rapid disappearance of tertian and crescents, the latter not accompanied by a corresponding fall in the subtertian rate, rendering the value of $\frac{c}{t}$ a low one. The spleen rate, which in Semarang and Magaredjo was nearly equal in the younger children, remains constant or even rises a little in the former place, whereas it decreases considerably in Magaredjo. The percentage of parasite carriers without enlarged spleen was low in the younger classes of Margaredjo, as was to be expected in an endemic region, but it rose in the elder children. The reduction of the average splenic enlargement, although present, is not considerable. The only crescent carrier among the children of 10 to 11 years is non-infective (one crescent per three thousand leucocytes).

V. SUMMARY

If we try to formulate as concisely as possible the results of quininisation mentioned above, we may say that in epidemic districts it alters the nature of the parasite infection among the inhabitants, causing it to approach the endemic type, and this the more markedly and completely the longer the treatment (taken as a whole, not each case individually) lasts. This seems a poor result, but it is not so if the transformation is complete. It considerably reduces the chances of infection in such districts. This will become apparent when comparing the rate of natural infection of *M. ludlowi* in epidemic and endemic regions. In the latter we found 143 infected out of 5,613, *i.e.*, 2·6 per cent.; in the former 122 out of 611, *i.e.*, 20 per cent. The latter rate is so high because not only the children but the adults also include numerous infective gamete carriers, whereas in endemic regions only the children do so. The quinine treatment greatly reduces the number of crescent carriers among the adults, and we may expect that the chances for Anophelines to become infected are in that way reduced by a ratio corresponding to the above figures.

In endemic areas conditions are different. Here the children only are the gamete reservoirs, and if it is difficult to cure them in epidemic regions, it is doubly so in endemic. We would encounter fewer difficulties with the adults, but there is no use in treating them, because of their limited epidemiological significance. Here endeavours will be successful only under special and favourable conditions as in Margaredjo. Terburgh (1919) has vividly described the hopelessness of the prospect if such conditions are absent.

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Table I.

Blood and spleen examinations. Semarang I-II. Population: 13,687
(cf. Chart No. 2).

Age in years	Number examined*	Spleen rate	Infection Rate					$\frac{c}{t}$
			Simple Tertian	Quartan	Sub-tertian	Crescents		
						Total	Infective	
0- 3	39 (151)	71	16	...	20	15	...	...
4- 5	39 (107)	81	13	7	31•	18	...	...
6- 7	100 (228)	79	8	7	12	6	...	...
8-11	111 (288)	82	6	3	13	11	...	...
12-15	74 (180)	85	4	3	9	8	...	...
16-20	73 (222)	82	5	...	9	3	...	...
21-30	264 (595)	87	3	0.5	8.5	3	...	...
31 and upwards	263 (726)	74	1	1	5	2	...	...
0-15	363 (954)	80	8	4	15	10	4	0·7
16 and upwards	601 (1543)	80	2.6	0.8	6	2	0.4	0·3

* The number in brackets indicates the number of spleen examinations; the other figure the number of blood *and* spleen examinations.

TABLE II.

Shewing the number of infections of simple tertian, quartan, subtertian (trophozoites and crescents) associated with the various degrees of splenic enlargement.

Degree of splenic enlargement	SIMPLE TERTIAN		QUARTAN		SUBTERTIAN			
					Trophozoites		Crescents	
	Number infected	Percentage of all tertian infections	Number infected	Percentage of all quartan infections	Number infected	Percentage of all tropho-zoite infections	Number infected	Percentage of all crescent infections
No enlargement ...	64	21	7	11	118	17	88	15
I and II*	125	41	24	37	286	41	253	42
III and IV* ...	97	32	28	43	255	37	227	38
V* and more ...	16	6	6	9	33	5	27	5
Average enlargement		2·5		2·8		2·6		2·5

* For explanation of these figures, *vide* Table XV.

TABLE III.

Shewing the number of crescents in relation to the number of trophozoites parasites.

Number of cases	Number of trophozoites	NUMBER OF CRESCENT CASES				Total	Percent-age*
		1 crescent per 1-100 leucocytes		1 crescent per 101 and more leucocytes			
		Total	Percent-age*	Total	Percent-age*		
207	100 and more per 50 leucocytes	66	8·4	41	5·2	107	13·6
517	1-500 per 500 leucocytes ...	136	17·3	104	13·3	240	30·6
621	1 and less per 3000 leucocytes ...	206	25·7	231	30·1	437	55·8

* *i.e.*, Percentage of the total number of crescent cases found (784).

TABLE IV.

Blood and spleen examinations in Tandjong-Pinang and Penjengat (Riouw Archipelago).
Population: Tandjong-Pinang, 660; Penjengat, 895
(cf. Chart No. 3).

	Age in years	Number examined*	Spleen rate	Infection Rate				c/t
				Simple tertian	Quartan	Sub-tertian	Crescents	
Tandjong-Pinang	0-15	113 (174)	68	11	12	18	7	0·4
"	16 and upwards	96 (124)	73	10	5	9	1	0·1
Penjengat	0-15	66 (129)	69	9	24	4	...	...
"	16 and upwards	31 (190)	30	13	6	...	...	...

* The number in brackets indicates the number of spleen examinations; the other figure, the number of blood *and* spleen examinations.

TABLE V.

Blood and spleen examinations in Tegal. Population. A, 6184: B, 2653.
(cf. Chart No. 4).

Age in years		Number examined*	Spleen rate	Infection Rate					c/t
				Simple Tertian	Quartan	Sub-tertian	Crescents		
							Total	Infective	
A†	0-15	260 (374)	62	4	1·5	15	6·5	3	0·4
	16 and upwards	244 (657)	65	...	0·4	9·4	0·8	...	0·09
B†	0-15	131 (167)	45	5	...	22	11	6	0·5
	16 and upwards	107 (196)	54	2	...	14	7	4	0·5

* The number in brackets indicates the number of spleen examinations, the other figure the number of blood *and* spleen examinations.

†A: An endemic region. †B: A sub-endemic region with epidemic exacerbations.

TABLE VI.

Blood and spleen examinations in Semarang III. Population 13,855.
(cf. Chart No. 5).

Age in years	Number examined*	Spleen rate	Infection Rate.			
			Simple tertian	Quartan	Subtertian	Crescents
0- 3	56 (198)	34	7	...	2	...
4- 5	52 (144)	51	11	2	6	4
6- 7	108 (274)	40	4	...	7	3
8- 11	134 (352)	40	3	1	5	2
12-15	69 (182)	44	1.5	...	1.5	1
16-20	60 (220)	52	1.5	1.5	7	7
21-30	201 (567)	45	0.5	0.5	2	1
31 and upwards	248 (637)	41	0.4	0.4	2	1

* The number in brackets indicates the number of spleen examinations, the other figure, the number of blood *and* spleen examinations.

TABLE VII.

Blood and spleen examinations in Semarang IV. Population 36,978.
(cf. Chart No. 6).

Age in years	Number examined*	Spleen rate	Infection Rate.			
			Simple tertian	Quartan	Subtertian	Crescents
0- 3	67 (384)	11	...	...	1	1
4- 5	66 (286)	17	1	...	3	3
6- 7	232 (790)	20	2.5	1	2.5	2
8-11	187 (854)	21	2	...	1	0.5
12-15	125 (527)	19	1	...	1	1
16-20	70 (498)	21	...	...	...	...
21-30	211 (1014)	20	0.5	...	0.5	0.4
31- and upwards	196 (1271)	19	0.5	0.5	...	...

* The number in brackets indicates the number of spleen examinations, the other figure, the number of blood *and* spleen examinations.

Table VIII.

Blood and spleen examinations in North Soendatar. Population 1,264.
(cf Chart No. 7)

Age in years	Number examined	Spleen rate	Infection Rate				$\frac{c}{t}$
			Simple tertian	Quartan	Subtertian	Crescents	
0- 5	129	81	26	12	65	46	
6- 9	100	96	22	4	77	54	0·7
10-15	69	87	12	13	59	43	
16-20	86	93	13	5	78	50	
21-30	95	84	16	3	54	40	0·6
31-and upwards	139	85	6	4	37	21	

Table IX.

Blood and spleen examinations in South Soendatar. Population 1,031.
(cf. Chart No. 8).

Age in years	Number examined	Spleen rate	Infection Rate				$\frac{c}{t}$
			Simple Tertian	Quartan	Subtertian	Crescents	
0- 5	113	24	4	2	18	11	
6- 9	75	21	4	1	19	16	0·7
10-15	37	20	3	3	13	13	
16-20	77	30	8	1	25	18	
21-30	59	29	2	7	13	7	0·7
31 and upwards	87	30	2	1	16	14	

Table X.

Blood and spleen examinations in Modjodjedjer. Population 640.
(cf. Chart No. 9).

Age in years	Number examined	Spleen rate	Infection Rate				$\frac{c}{t}$
			Simple Tertian	Quartan	Subtertian	Crescents	
0- 5	97	32	12	...	18	6	
6- 9	129	37	19	...	24	12	0·4
10-15	73	40	9	...	41	18	
16-20	79	39	9	...	38	19	
21-30	88	34	10	...	24	9	0·4
31 and upwards	90	30	3	...	22	15	

Table XI.

Blood and spleen examinations before and after quininisation in North Soendatar.
(cf. Charts Nos. 10 and 14).

Age in years	Number examined	Spleen rate	Infection Rate.					$\frac{c}{t}$	Percentage of parasite cases without enlarged spleen
			Simple tertian	Quartan	Sub-tertian	Crescents			
						Total	Infective		
Before the treatment.									
0-15	298	90	21	9	68	48	28	0·7	0·9
16 and upwards	320	87	11	4	53	34	18	0·6	2
After the treatment.									
0-15	235	90	10	0·4	62	41	20	0·7	6
16 and upwards	196	73	4	...	39	21	9	0·5	26

TABLE XIA.

Results of quininisation of a definite group of individuals in North Soendatar examined before and after a month's treatment. (cf. Chart No. 10A).

Age in years	Number examined	Infection Rate: Simple tertian	Quartan	Sub-tertian	Crescents: Total	Infective	c/t	Spleen rate	Average splenic enlargement	Average reduction of enlargement	Percentage of parasite cases without enlarged spleen
Before the treatment											
0-15	105	25	10	79	56	34	0·7	86	3·1	...	6
16 and upwards	105	8	1	63	48	25	0·8	89	2·9	26 %	8
After the treatment											
0-15	90	17	3	71	50	34	0·7	84	2·3	...	12
16 and upwards	90	4	...	49	29	10	0·6	65	2·1	27 %	29

TABLE XII.

Blood and spleen examinations, before and after quininisation in South Soendatar. (cf. Charts Nos. 11 and 14).

Age in years	Number examined	Spleen rate	Infection Rate: Simple tertian	Quartan	Sub-tertian	Crescents: Total	Infective	c/t	Percentage of parasite cases without enlarged spleen
Before the treatment.									
0-15	225	21	4	2	18	13	9	0·7	28
16 and upwards	223	29	4	3	18	13	9	0·7	28
After the treatment.									
0-15	94	40	6	1	30	18	9	0·6	33
16 and upwards	102	30	1	1	27	8	2	0·3	78

TABLE XIII.

Blood and spleen examinations in Modjodjedjer

A At the onset of the epidemic (June).
B During house to house quininisation (July).
C After three months quininisation (September).
(cf. Charts Nos. 11, 14 and 15).

Time	Age in years	Number examined	Spleen rate	Infection Rate					c/t	Percentage of parasite cases without enlarged spleen
				Simple tertian	Quartan	Sub-tertian	Crescents			
							Total	Infective		
June ...	0-15	197	37	14	...	25	10	3	0·4	22
	16 and upwards	184	32	9	...	26	13	5	0·5	34 (43-26)*
July ...	0-15	102	34	13	...	29	14	11	0·5	46
	16 and upwards	72	39	7	...	32	18	9	0·6	46 (54-40)*
Sept. ...	0-15	138	59	19	3	22	16	8	0·7	9
	16 and upwards	113	26	0·9	6	11	2·6	0·8	0·2	55 (77-4)*

* The figures in brackets give the percentage, mentioned at the head of the column, for men and women separately. The first figure refers to men and the second to women.

TABLE XIV.

Blood and spleen examinations of the school-children of Margaredjo compared with those of children of similar age in Semarang I-III

(cf. Chart Nos. 13 and 14).

Age in years	Number examined*	Spleen rate	Infection Rate					c/t	Percentage of parasite cases without enlarged spleen
			Simple Tertian	Quartan	Sub-tertian	Crescents			
						Total	Infective		
			MARGAREDJO						
6-9	105	64	6	1	22	15	9	0·7	7
10-11	40	45	2·5	...	22·5	2·5	...	0·1	39
12-13	59	32	...	...	13	...	...	...	
			SEMARANG I-III.						
6-7	208	58	5	3	10	4	1	0·4	8
8-11	245	59	4	2	8	6	3	0·7	
12-15	143	64	3	1	5	5	3	1·0	

* All the school children were examined.

TABLE XV.

Splenic enlargement before and after quinine treatment.

Locality	Before or after the treatment	Children or Adults	Classes of enlargement*									Average of † enlargement	Average reduction
			0	I	II	III	IV	V	VI	VII	VIII		
SOUTH SOENDATAR ...	before	children	178	24	7	9	7	...	...	...	...	2·0	...
		adults	157	35	14	6	10	1	...	...	...	1·9	...
	after	children	56	17	14	5	2	...	...	...	...	1·8	+ 10 %
		adults	71	23	6	...	2	...	...	...	...	1·4	+ 26 %
NORTH SOENDATAR ...	before	children	34	38	60	60	92	27	4	...	...	3·1	...
		adults	45	60	51	82	81	22	9	...	...	2·9	...
	after	children	24	66	56	44	38	7	...	...	...	2·3	+ 26 %
		adults	53	62	34	28	15	4	...	...	...	2·0	+ 31 %
MODJODJEDJER ...	before	children	192	72	19	11	5	...	...	...	...	1·5	...
		adults	174	67	14	4	2	...	...	...	...	1·3	...
	after	children	36	19	10	8	10	...	...	...	...	1·8	– 20 %
		adults	28	6	2	1	3	...	...	...	...	2·1	– 61 %
MARGAREDJO	before	children	38	28	15	14	9	1	...	...	...	2·1	...
	after	children	62	20	5	8	2	2	...	...	...	1·9	+ 9 %

* The degree of enlargement is determined as follows :—Draw a line from the angle of the 9th rib, through the umbilicus, to the right anterior superior spine of the ilium. This line has three fixed points : the umbilicus and the points of junction with the rib and the ilium. The portions of the line above and below the umbilicus are divided into four equal parts, by plotting out on the line nine equidistant points, numbered 1-9, No. 1 being the junction with the rib, No. 5 the umbilicus and No. 9 the junction with the ilium. Now we call (Schüffner and Swellengrebel, 1918):

A spleen just palpable reaching point No. 2 : splenic enlargement I.
A spleen passing point No. 2, reaching point No. 3 : splenic enlargement II.
A spleen passing point No. 4, reaching the umbilicus : splenic enlargement IV., etc.

† To determine this average. to spleens of Class I is ascribed a value 1, to spleens of Class II a value 2, etc.
e.g. The average of enlargement of the spleens of the children of South Soendatar is :—

$$\frac{(24 \times 1) + (7 \times 2) + (9 \times 3) + (7 \times 4)}{24 + 7 + 9 + 7}$$

$$i.e., \frac{93}{47} = 1{\cdot}97 = 2.$$

Ross (1910) and others have described similar methods for expressing in a simple way the degree of splenic enlargement.

TABLE XVI.

Number of crescents in the districts under observation.

Locality	Number of gamete cases observed	Number of cases where one crescent was found per leucocytes: 10-20	21-50	51-100	101-200	201 +	Percentage of highly infective cases	Children or Adults
SEMARANG I, II ...	43	5	8	5	2	23	42	children
	19	2	1	1	...	15	20	adults
SEMARANG III—V ...	17	1	4	2	...	10	41	children
	9	3	2	2	...	2	77	adults
TEGAL— Endemic	17	5	2	1	...	9	46	children
	2	...	...	...	...	2	...	adults
Sub-endemic ...	15	5	2	1	...	7	53	children
	7	1	3	...	...	3	57	adults
MODJODJEDJER— Before quininisation	33	6	8	3	1	15	51	children
	36	6	7	2	2	19	42	adults
After quininisation	22	2	5	4	1	10	50	children
	3	...	1	...	...	2	33	adults
SOUTH SOENDATAR— Before quininisation	29	6	7	6	...	10	66	children
	33	6	11	7	...	9	72	adults
After quininisation	17	4	3	2	1	7	52	children
	8	1	1	...	1	5	25	adults
NORTH SOENDATAR— Before quininisation	143	43	31	9	13	47	58	children
	110	21	23	16	4	46	54	adults
After quininisation	97	13	28	7	7	42	49	children
	43	5	12	2	4	20	44	adults
MARGAREDJO— 6-9 years of age ...	16	5	4	1	...	6	62	children
10-13 years of age ...	1	...	...	...	...	1	...	children

TABLE XVII

Showing spleen rate of children and adults in some of the islands of the Australian division of the Malay Archipelago.

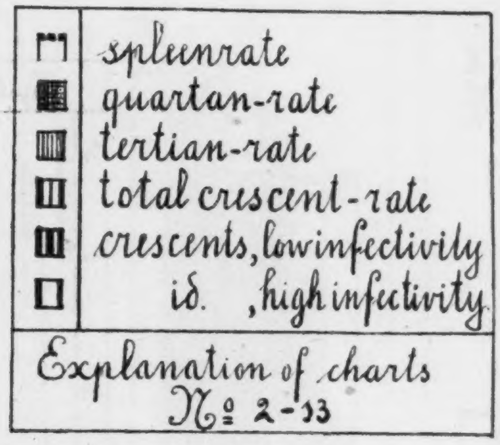
Locality	Children		Adults	
	Number examined	Spleen rate	Number examined	Spleen rate
Ternate	121	78 %	44	70 %
Gilolo	19	100 %	22	82 %
Small islands between Halmaheira and Amboina	65	71 %	41	73 %
Amboina*	276	93 %	184	87 %
Ceram	126	93 %	56	84 %
Western New Guinea	25	72 %	32	84 %
Total	632	87 %	379	83 %

* Highly infected part of the island.

TABLE XVIII.

Showing percentage of mixed infections among the parasite cases.

Locality	Children			Adults		
	Number of parasite cases.	Number of mixed infections	Percentage	Number of parasite cases	Number of mixed infections	Percentage
MODJODJEDJER—						
Before quininisation ...	127	8	6	93	3	3
After quininisation ...	53	5	9	21	1	5
SOUTH SOENDATAR						
Before quininisation ...	43	9	21	51	7	14
After quininisation ...	34	4	12	27	1	4
MARGAREDJO—						
Before quininisation ...	29	...	...	...	...	...
After quininisation ...	18	...	...	...	...	...
TEGAL—						
Endemic	50	4	8	25	...	...
Sub-endemic	34	2	6	15	2	13
SEMARANG—						
I-II	91	8	9	67	2	3
III	38	...	...	18	1	5
IV	26	...	...	6	...	...
RIOUW—						
T. pinang	47	4	8	22	3	14
Penjengat	24	1	4	6	...	...
NORTH SOENDATAR—						
Before quininisation ...	230	56	24	181	30	16
After quininisaton ...	154	16	10	85	2	2



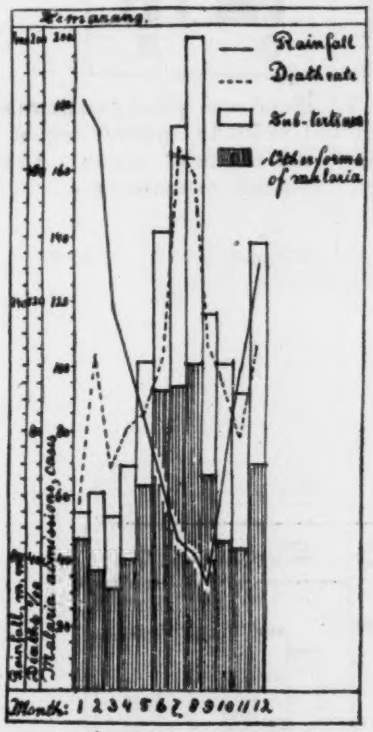


CHART 1. Malaria admissions to the native hospital, rainfall and death-rates in Semarang.

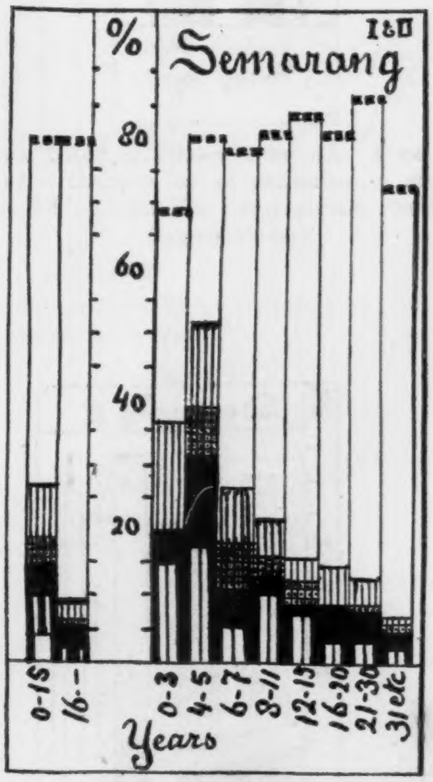


CHART 2. Littoral districts of Semarang, endemic area. Blood and spleen examinations in children and adults (left), arranged according to the age (right).

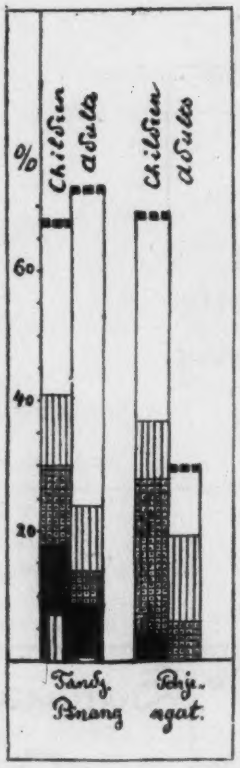


CHART 3. Aberrant results of blood and spleen examinations in an endemic region (Riouw Archipelago: Tandjong Pinang and Penjengat)

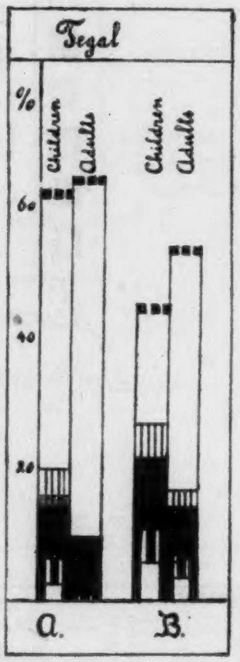
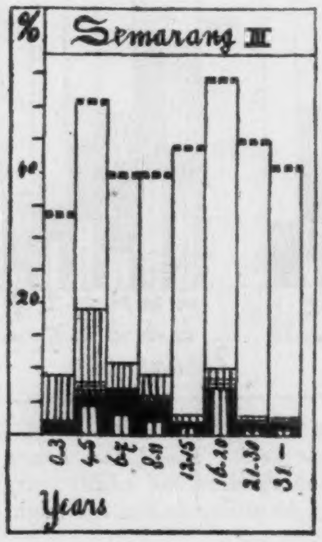
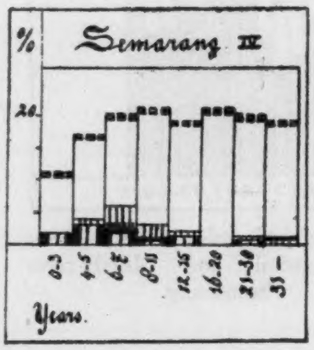


CHART 4. Blood and spleen examinations in children and adults in endemic region and adjoining sub-endemic region, showing epidemic exacerbation.





CHARTS 5 and 6. Blood and spleen examinations in sub-endemic regions arranged according to the age (Semarang).

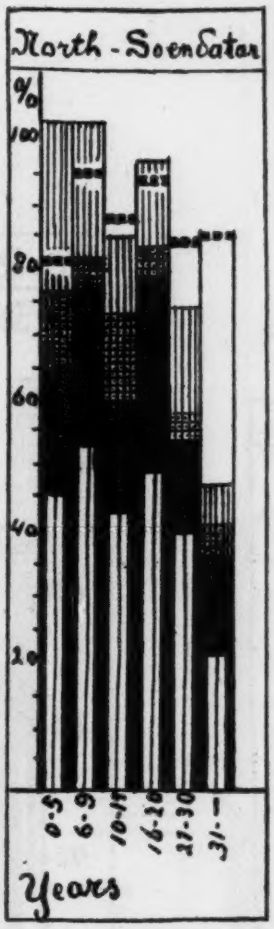
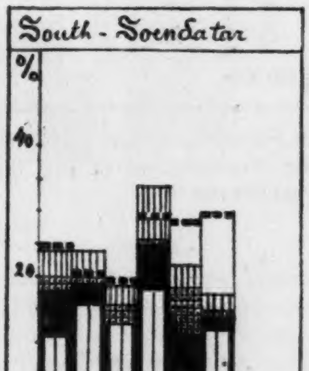
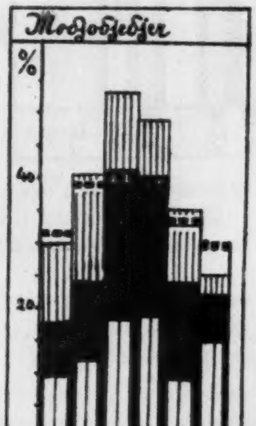


CHART 7. Blood and spleen examinations in epidemic region of high endemicity, arranged according to the age (North Soendatar).





CHARTS 8 and 9. Ibid. in epidemic region of lower malarial frequency. (South Soendatar and Modjodjedjer).

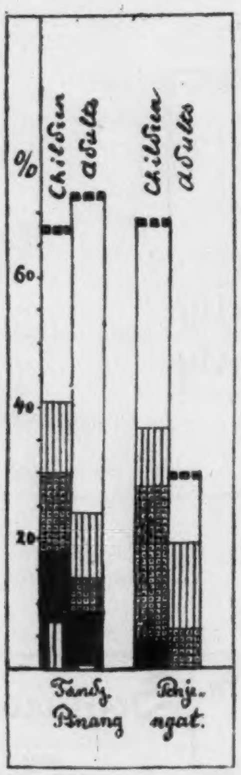
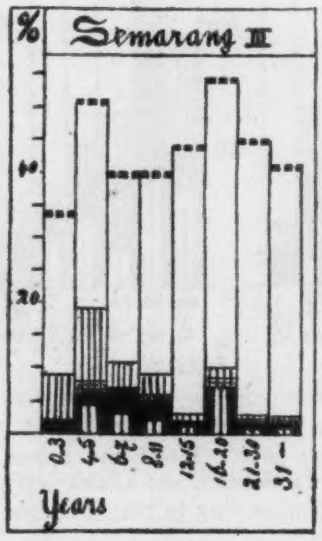
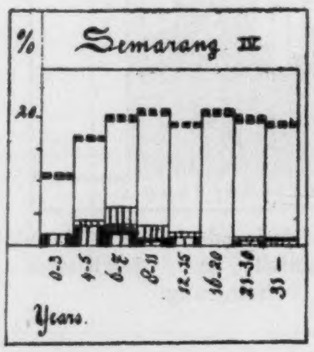


CHART 3. Aberrant results of blood and spleen examinations in an endemic region (Riouw Archipelago: Tandjong Pinang and Penjengat)

CHART 4. Blood and spleen examinations in children and adults in endemic region and adjoining sub-endemic region, showing epidemic exacerbation.





CHARTS 5 and 6. Blood and spleen examinations in sub-endemic regions arranged according to the age (Semarang).

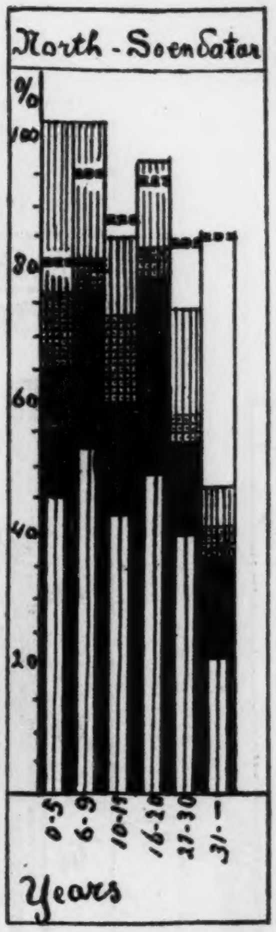
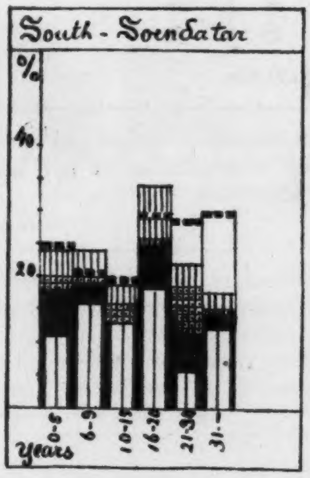
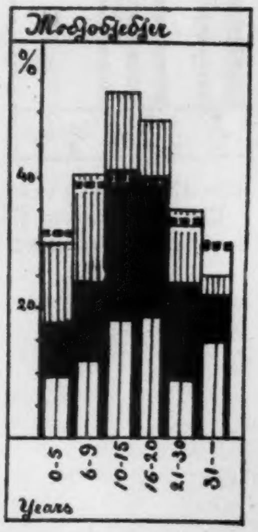
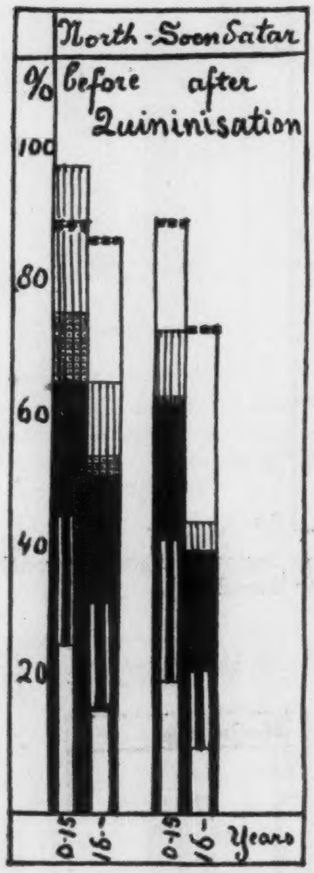


CHART 7. Blood and spleen examinations in epidemic region of high endemicity, arranged according to the age (North Soendatar).





CHARTS 8 and 9. Ibid. in epidemic region of lower malarial frequency. (South Soendatar and Modjodjedjer).



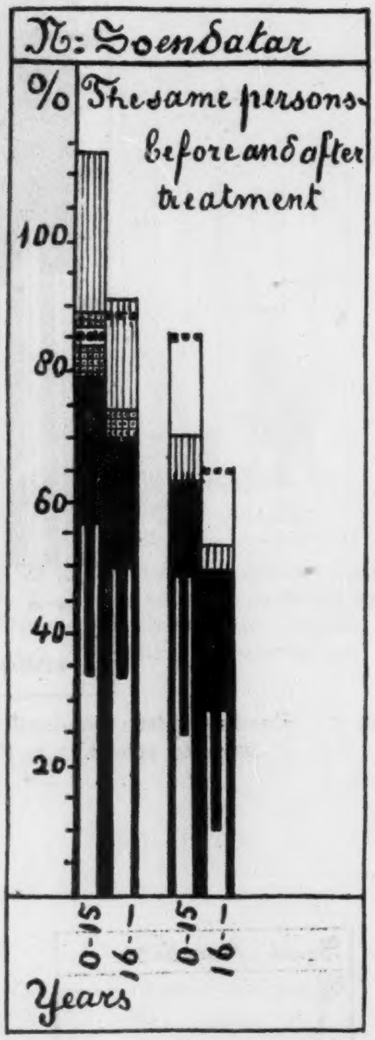


CHART 10. Blood and spleen examinations in North Soendatar, before and after quinine treatment.
CHART 10A gives the result of similar examinations of 195 individuals examined before and after treatment.

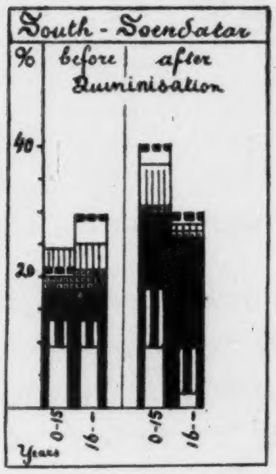


CHART 11. Ibid. in South Soendatar.

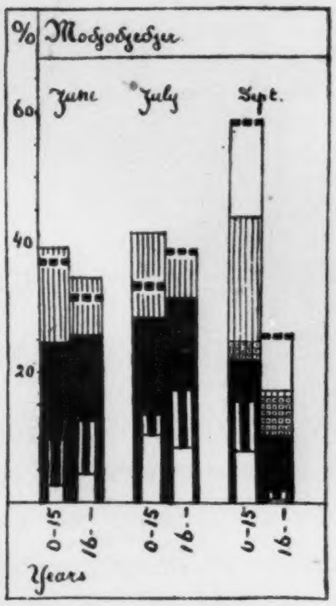


CHART 12. Blood and spleen examinations in Modjodjedjer: at the beginning of the epidemic (June), during the house-to-house quinine distribution (July) and after two additional months of treatment at the clinic.

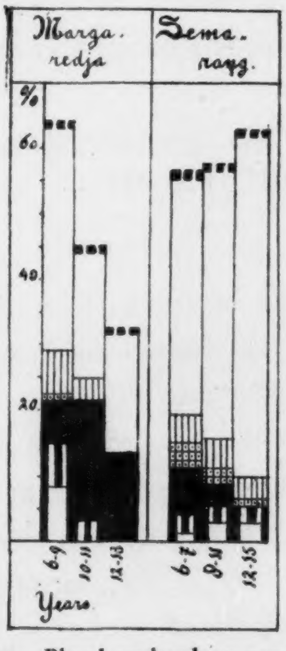


CHART 13. Blood and spleen examinations of school-children in Margaredjo, arranged in classes according to their subjection to the treatment for a longer or shorter period. For comparison: Children in Semarang I-III of the same age.

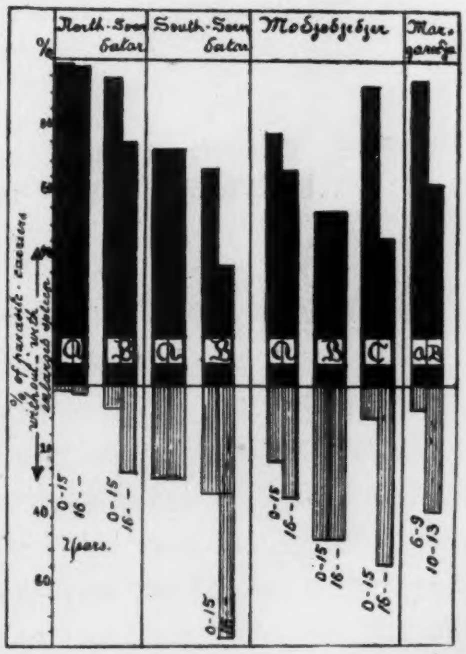


CHART 14. Percentage of parasite cases without enlarged spleen.

North Soendatar, South Soendatar:
- A. Before treatment.
- B. After treatment.

Modjodjedjer:
- A. Beginning of the epidemic.
- B. House-to-house quinine distribution.
- C. After two additional months of treatment at the clinic.

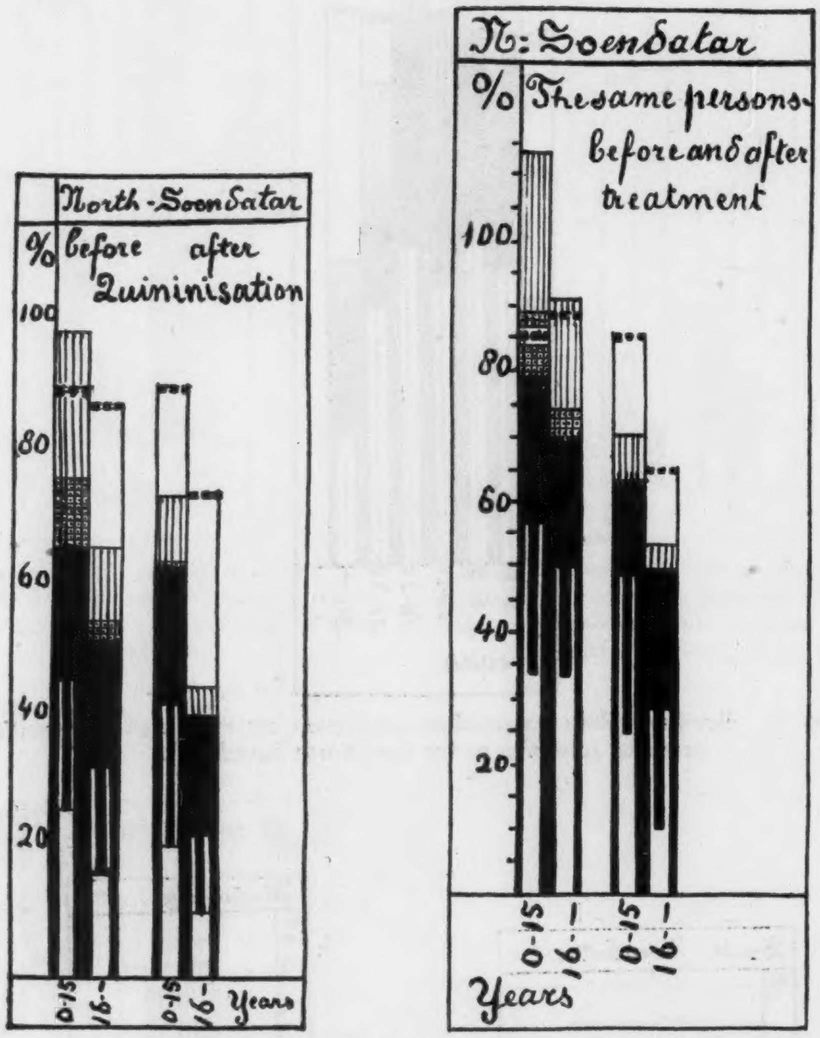


CHART 10. Blood and spleen examinations in North Soendatar, before and after quinine treatment.
CHART 10A gives the result of similar examinations of 195 individuals examined before and after treatment.

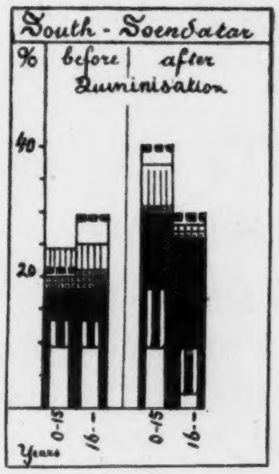


CHART 11. Ibid. in South Soendatar.

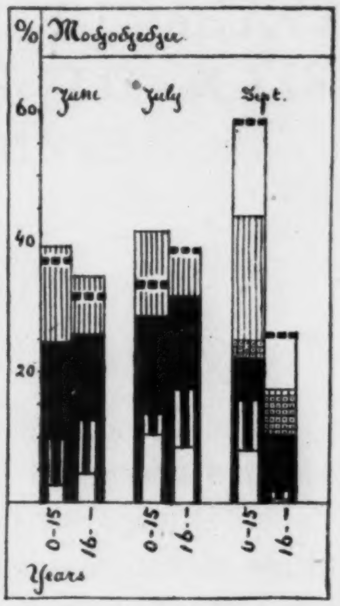


CHART 12. Blood and spleen examinations in Modjodjedjer: at the beginning of the epidemic (June), during the house-to-house quinine distribution (July) and after two additional months of treatment at the clinic.

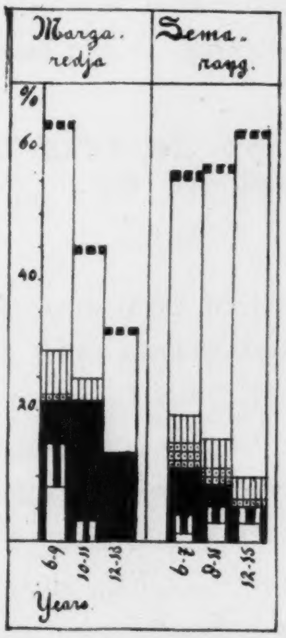


CHART 13. Blood and spleen examinations of school-children in Margaredjo, arranged in classes according to their subjection to the treatment for a longer or shorter period. For comparison: Children in Semarang I-III of the same age.

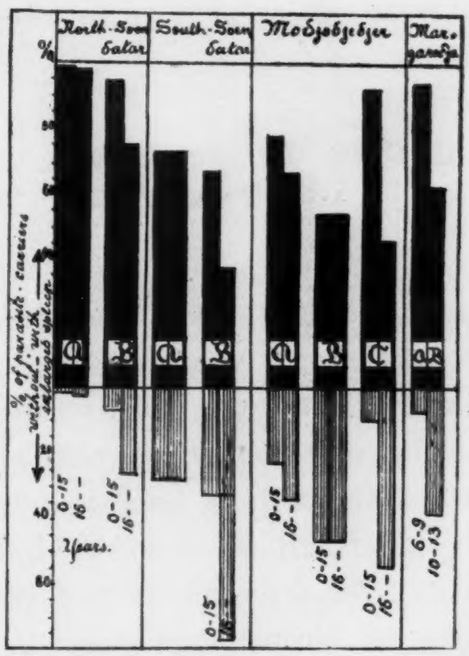


CHART 14. Percentage of parasite cases without enlarged spleen.

North Soendatar, South Soendatar:
- A. Before treatment.
- B. After treatment.

Modjodjedjer:
- A. Beginning of the epidemic.
- B. House-to-house quinine distribution.
- C. After two additional months of treatment at the clinic.

HEAT AND *STEGOMYIA FASCIATA*: SHORT EXPOSURES TO RAISED TEMPERATURES

BY

J. W. S. MACFIE

(*Received for publication* 6 *May*, 1920)

Early in the course of these experiments on the effects of heat on *Stegomyia fasciata* it was found that the results were materially influenced by three factors, namely, (1) the manner in which the heat was applied, (2) the length of time occupied in reaching the particular temperature, and (3) the length of time the temperature was maintained. In the first instance, therefore, the effects of exposure for a short period (five minutes) were studied; the results observed are recorded in the following pages. It is hoped to investigate the effects of longer exposures as soon as the necessary apparatus can be procured.

THE EFFECTS OF EXPOSURE FOR A SHORT PERIOD TO AN INCREASE OF TEMPERATURE

EGGS

The eggs used in the first experiments (Nos. 1 to 8) had been laid on filter-paper, and had been preserved dry for a fortnight. Small pieces of the filter-paper, each with ten eggs attached, were cut off and put dry into glass tubes; they were then flooded with water at the required temperature, maintained at that temperature for five minutes, and then allowed to cool at the laboratory temperature (28° C.). A control was put up for each experiment, the eggs being flooded with water at the temperature of the air in the laboratory. Only unshrunken eggs were used. Finally a loop-full of faeces was added to each tube. The tubes were watched for one week.

The effects on the eggs of immersion in this manner for five minutes in water heated to various temperatures are summarised in Table I.

TABLE I.

Experiments on dried eggs immersed in water.

Experiment No.	Temperature	Number of eggs used	Number of larvae which hatched	Remarks	Control Tubes: Number of eggs used	Control Tubes: Number of larvae which hatched	Control Tubes: Remarks.
	°C.						
1	49	10	...	Eggs did not uncap.	10	10	
2	48	10	1	Hatched on the third day	10	8	Only seven left on the sixth day.
3	47	10	2	One hatched on the first day, and one on the third.	10	10	
4	46	10	8		10	10	
5	45	10	10	Only nine left on the seventh day.	10	8	
6	44	10	9		10	10	Only five left on the sixth day.
7	43	10	10		10	9	
8	42	10	10	Only seven left on the sixth day.	10	10	Only six left on the sixth day.

The eggs appeared to withstand successfully temperatures as high as 46° C.; they were generally killed at temperatures higher than this, and none hatched of those which had been submitted to a temperature of 49° C.

Somewhat similar experiments were carried out with recently laid eggs, that is with eggs which had been laid less than forty-eight hours and which had not been allowed to dry. The eggs had been deposited on wet filter-paper about twenty-four hours before the experiments were started. Pieces of the filter-paper with eggs attached were exposed to different temperatures, the technique employed being similar to that in the experiments with adults (see p. 7) excepting that sufficient water was present in the vessels to keep the eggs moist. After five minutes' exposure to the particular temperature to be tested, the slip of filter-paper was flooded with water at the temperature of the air in the laboratory.

The results of two such experiments, combined and summarised in Table II, were similar to those with dried eggs.

TABLE II.

Experiments on recently laid eggs.

Experiment No.	Temperature	Number of eggs used	Number of larvae which hatched	Controls	
				Number of eggs used	Number of larvae which hatched
	°C.				
9	49	20	0	15	11
10	47	20	4	15	9
11	45	44	33	40	27

Eggs were also subjected to various temperatures in a dry condition; the technique employed being similar to that used in the experiments with adults (see p. 7). The eggs had been laid on filter-paper, and had been preserved dry for two months. Immediately after exposure the eggs were flooded with water at the temperature of the air in the laboratory. Only unshrunken eggs were used. The results are summarised in Table III.

TABLE III.

Experiments on eggs in a dry condition.

Experiment No.	Temperature	Number of eggs used	Number of larvae which hatched	Controls	
				Number of eggs used	Number of larvae which hatched.
	°C.				
12	49	10	0	10	10
13	47	10	1	7	6
14	45	5	4	6	6

The effects of exposure for five minutes to various temperatures were similar on (1) recently laid eggs which had not been dried, and on (2) dried eggs either with or without water: a temperature of 49° C. was fatal to all, and a temperature of 47° C. to most of the eggs used; a temperature of 45° C. had no appreciable ill-effect.

Larvae

These experiments were conducted in a water-bath, kept at a constant temperature, in which there floated a small and thin-walled glass vessel or beaker. The larvae for an experiment were placed in the beaker and freed from water by means of a pipette. The beaker was then immersed in the water-bath and half filled with the heated water. Care was taken to arrange that the beaker should float in the water-bath and that the surface of the water in it should be lower than that in the water-bath. The temperature was read on a thermometer held in the beaker.

The experiments lasted five minutes each. At the end of this time the beaker was lifted out of the water-bath and allowed to cool at the temperature of the air in the laboratory (27° to 28° C.).

The larvae used were in the final stage of their development. The effects upon them of immersion for five minutes in water heated to various temperatures are summarised in Table IV.

Table IV.

Experiments on larvae.

Experiment No.	Temperature	Number of larvae used in the experiment	State after five minutes' exposure.	Final result
	°C.			
15	50	6	All inert	None revived.
16	47-48	6	All inert	None revived
17	46-47	6	All inert	None revived.
18	46	10	All inert	Two revived partially, but died within one day.
19	45	6	All inert	Two revived partially, but died within one day.
20	44	10	All inert	Seven revived partially; four of these died within one day, and three pupated but died soon afterwards with the larval pelt still attached to their fins.
21	43	10	None inert, but all profoundly affected	Five died as larvae, one died pupating, four pupated and hatched. The mosquitoes produced fertile eggs.
22	42	10	None inert, but all considerably affected	Five died as larvae, one died pupating, four pupated and hatched. The mosquitoes produced fertile eggs.
23	41	10	All alive, but affected slightly	All revived, pupated, and hatched. The mosquitoes produced fertile eggs.
24	40	6	All alive and active	All pupated and hatched. The mosquitoes produced fertile eggs.

Immediate results. After five minutes' immersion in water heated to 44° C. or higher the larvae were all inert, and generally lay either at the bottom of the beaker or flat on the surface of the water; at slightly lower temperatures (41° to 43° C.) the effect was similar but slighter, the larvae being sluggish or showing signs of life only when disturbed; temperatures of 40° C. and under did not have any apparent deleterious effect.

Final results. Larvae rendered inert by immersion in heated water sometimes recovered after being removed from the water-bath. In some cases the recovery was only temporary or partial; in other cases it was complete, that is, the larvae became normally active and subsequently completed their development. In a few cases the larvae recovered completely to all appearances, but when they pupated they were unable to free themselves from the larval pelt which adhered to their paddles and interfered with their movements to such a degree that they died in a short time.

In the experiments summarised in Table IV the larvae seldom survived temperatures above 43° C., and suffered no permanent ill-effects from temperatures under 42° C.; no recovery was observed after exposure to temperatures of 47° C. or higher, and no complete recovery after exposure to temperatures above 43° C.

PUPAE

The experiments with pupae were carried out in the same manner as those with larvae. The effects on the pupae of immersion for five minutes in water heated to various temperatures are summarised in Table V.

Immediate results. After five minutes' immersion in water heated to 44° C. or higher the pupae were all inert and lying at the surface; the higher the temperature the more rapidly the pupae were effected in this manner. At slightly lower temperatures (42° to 43° C.) the effect was similar but slighter, the pupae being sluggish and having a tendency to remain at the surface, or showing signs of life only when disturbed. Temperatures of 41° C. and under did not have any apparent deleterious effect.

Final results. Pupae rendered inert by immersion in heated water sometimes recovered after being removed from the water-bath. The recovery was in some cases only temporary or partial; in others

it was complete, that is, the pupae became normally active and subsequently completed their development. In some cases the pupae appeared to have recovered completely, but the adult insects were unable to hatch from them or emerged imperfectly and so died,

Table V.

Experiments on pupae.

Experiment No.	Temperature	Number of pupae used in the experiment	State after five minutes' exposure	Final result.
	°C.			
25	50	6	All inert	None revived.
26	47–48	6	All inert	Three revived partially, but died within two days.
27	46–47	5	All inert	Two revived partially, but died within two days.
28	46	10	All inert	Eight revived; of these seven died within two days (three or more in the act of hatching), and one hatched, but the mosquito was not able to free itself completely from the pupal pelt.
29	45	6	All inert	Five revived; of these one died hatching, and four hatched.
30	44	10	All inert	Nine revived; of these one died within one day, one died hatching, and seven hatched. Five of the seven mosquitoes which hatched appeared to be more or less paralysed. One male and one female were isolated; fertile eggs were produced
31	43	10	None inert, but all affected	All revived and hatched; the mosquitoes produced fertile eggs.
32	42	10	None inert, but all somewhat affected	Nine revived and hatched; one mosquito was unable to free its hind legs from the pupal pelt. Five males and two females, which appeared normal, were isolated; fertile eggs were produced.
33	41	10	All alive and active	All hatched; the mosquitoes produced fertile eggs.
34	40	6	All alive and active	All hatched; the mosquitoes produced fertile eggs.

most commonly with the thorax protruded, or outstretched at the surface having failed to split the pupal case. Sometimes the mosquitoes withdrew completely, all but the ends of their legs. Not a few of the mosquitoes hatched from the pupae used in these

experiments appeared to be partially paralysed, their power of flight being particularly affected.

In the experiments summarised in Table V the pupae seldom survived temperatures above 45° C., and seldom suffered permanent ill-effects from temperatures under 44° C.; no recovery was observed in the pupae subjected to a temperature of 50° C., and no complete recovery after exposure to temperatures above 45° C.

The immediate effects of immersion in heated water on the larvae and pupae of *Stegomyia fasciata* are similar, both being rendered inert by subjection to a temperature of 44° C. or higher. The larvae when reduced to this state usually either sink or float parallel with the surface of the water; the pupae float at the surface. The final effects differ somewhat. Pupae appear to be more resistant than larvae, and recover more frequently and after subjection to higher temperatures. The heat, however, appears to have some action on the pupal case, making it more difficult to split and thus increasing the dangers incidental to eclosion. A corresponding effect was observed in only a few larvae, and was shown by the adherence of the larval pelt to the paddles of the pupa.

Adults

The experiments with adults were conducted in a small glass flask immersed in a water-bath kept at a constant temperature. At the bottom of the flask was a drop of water and a layer of lint or wool, across the middle a paper loop for the mosquitoes to alight on, and in the neck a plug of wool through which passed a thermometer. The flask was immersed up to the neck in the water-bath to a level about the middle of the woollen plug, and was held in position until the thermometer in it registered the required temperature. The plug was then withdrawn for a moment and the mosquitoes introduced enclosed in a small gauze bag folded in such a way that it opened immediately it was released. In each experiment the temperature was maintained for five minutes, after which the flask was removed and allowed to cool at the temperature of the air in the laboratory (28° C.).

The effects on the mosquitoes of exposure in this manner to various temperatures for five minutes are summarised in Table VI.

Immediate results. The mosquitoes exposed to temperatures of 41° C. or higher were all rendered inert; those exposed to 40° C. were profoundly affected but were not completely inactivated; and those exposed to 39° C. remained fairly active. At the higher temperatures the effect appeared to be almost instantaneous.

Final results. Mosquitoes rendered inert by exposure to high temperatures sometimes recovered after being removed from the

TABLE VI.

Experiments on Adults.

Experiment No.	Temperature	Number of mosquitoes used in the experament		State after five minutes' exposure	Final result
		Male	Female		
	°C.				
35	47	1	1	Inert	Did not revive.
36	46	3	6	Inert	Did not revive
37	45	2	2	Inert	Did not revive.
38	44	2	1	Inert	Did not revive.
39	43	1	7	Inert	Revived slowly, but partly paralysed. All but three females died within three days.
40	42	1	1	Inert	Revived slowly, but female partly paralysed; fertile eggs produced.
41	41	2	3	Inert	Revived.
42	40	2	3	Profoundly affected	Revived.
43	39	1	3	All more or less active	

water-bath, but the recovery was slow. In the experiments summarised in Table VI no recovery took place after exposure to temperatures of 44° C. or higher. After exposure to 43° C. the eight mosquitoes used in the experiment revived slowly: after twenty-four hours all eight were still alive but only four of them had revived sufficiently to be able to crawl about, and none could fly; after three days, three still survived, and of them only one eventually regained its usual activity. The wings appeared to be particularly affected, for mosquitoes which revived partially were usually able to walk but unable to fly, and others less affected sometimes were

unable to fold back the wings but held them permanently at right angles to the long axis of the body. The female mosquito in Experiment No. 40 had the right wing affected in this way, she was nevertheless able to fly, to suck blood, and to lay fertile eggs.

The mosquitoes used in the foregoing experiments had not been fed in any way. In order to determine if they were more susceptible to the action of heat in this state than after a meal fourteen mosquitoes (five males and nine females), which had previously been provided with honey-water, were exposed to a temperature of 44° C. in the manner already described. All were rendered inert, and showed no signs of life two hours after removal from the water-bath. Fifteen hours later two females were just alive, one with the right wing, and one with both wings outstretched and paralysed. Two days later both these mosquitoes had died without recovering further. The results of these experiments were, therefore, similar to those with fasting mosquitoes.

A trace of moisture was present in the flask in the foregoing experiments. One additional experiment was, therefore, made without this. Five mosquitoes (two males and three females) were exposed to a temperature of 41° C. for five minutes in the manner described, but in a dry flask. All were rendered inert. Subsequently all but one revived completely, but rather more slowly than in the previous experiment at this temperature (No. 41). One mosquito, a male, revived only partially; both his wings were paralysed and he survived only four days. The absence of moisture, therefore, appeared to have the effect of making the mosquitoes slightly more susceptible to the action of a raised temperature.

TABLE VII.

Comparison of effects.

Stage of development	Highest temperature survived by half or more without permanent injury	Lowest temperature survived by none without permanent injury
	°C.	°C.
Eggs	46	49
Larvae	41	44
Pupae	43	46
Adults	42	44

CONCLUSIONS

The ability of *Stegomyia fasciata* to withstand sudden exposure for five minutes to a raised temperature is greatest in the egg stage, slightly less in the pupal stage, and least in the larval and adult stages (see Table VII).

I.—ORAL ADMINISTRATION OF QUININE OR QUININE AND ARSENIC FOR SHORT PERIODS TO YOUNG NATIVE CHILDREN INFECTED WITH MALIGNANT TERTIAN MALARIA

BY

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AND

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The observations recorded in this paper were made at Accra, in the Gold Coast, West Africa, during the months of July and August, 1919.

All the patients were native children infected in the Gold Coast. In every instance a diagnosis of malignant tertian malaria was made microscopically, and in all cases trophozoites were present in the blood on the day treatment was begun. Except when otherwise indicated in the tables, blood examinations were made daily until the parasites disappeared from the cutaneous blood, and thereafter once a week during an after-treatment observation period of two months. In Tables I and IV, in the Remarks columns, the days referred to are days of the after-treatment observation period.

All the children, excepting No. 17, appeared to be healthy; some of them, however, had recently had fever, and all were heavily infected with malignant tertian malaria, the parasites being either numerous or very numerous in the blood. All excepting Nos. 3, 5, 7, 9, 12, 15, 16, 20 and 21 were boys.

The children were not admitted to hospital, but both during treatment and observation continued to live in their own homes and to go about as usual. For this reason temperature charts were not kept, but the parents were instructed to bring the children to the dispensary at once should they appear to be unwell. In the tables, therefore, a febrile lapse indicates a clinical attack of fever as complained of by the patient or detected by the parents.

It was not possible to guard against the possibility of reinfection, so that the observations might be expected to show if anything an undue preponderance of malaria relapses. As a matter of fact, Anopheline mosquitoes were very uncommon during the period covered by the observations, and six negative cases selected as controls did not become infected.

The quinine was administered by the mouth, in solution.

The following sets of observations were made:—

GROUP A

Quinine hydrochloride grains 10 orally were given in eight cases (Nos. 1 to 8), the treatment being continued for two consecutive days only in five cases, and for three, seven, and nine days respectively in the remaining three cases. The ages of the children varied from six months to seven years. The results of these treatments are recorded in Table I.

TABLE I.

Summary of results of oral administration of quinine hydrochloride grains 10 to native children in malignant tertian malaria.

Number of case	Age in years	Date of end of treatment	Number of days on which treatment was given	Trophozoites disappeared from cutaneous blood in — days after first dose	Trophozoite relapse occurred in — days after last dose	Febrile relapse occurred in — days after last dose	Remarks
1	6/12	30.7.19	2	2	8–14	...	No febrile relapse in eight weeks.
2	3	31.7.19	2	1	7–14	...	No febrile relapse in five weeks.
3	4	9.8.19	2	Present throughout	...	...	No fever. Quinine and arsenic administered on the 3rd day.
4	5	31.7.19	2	Present throughout	...	...	No fever. Quinine and arsenic administered on the 12th day.
5	7	30.7.19	2	2	8–14	...	No febrile relapse in eight weeks.
6	9/12	8.8.19	3	Present throughout	...	...	No fever. Quinine and arsenic administered on the 4th day.
7	2	6.8.19	7	Present throughout	...	...	Fever on the 6th day: quinine administered.
8	7/12	9.8.19	9	Present throughout	...	...	No fever. Quinine and arsenic administered on the 3rd day.

In one case (No. 8) the temperature fell to normal in one day; in the remaining seven cases treatment was commenced during an apyrexial period; three cases (Nos. 3, 6 and 7) had had fever the previous day.

In five cases trophozoites were present throughout, in the remaining three cases they disappeared from the cutaneous blood within two days. None of the patients had attacks of fever during the treatments.

Relapses. In five cases trophozoites did not disappear from the cutaneous blood; all remained positive at least a week, notwithstanding the fact that in some treatment had been restarted before the seventh day. In the three remaining cases, those which became negative, trophozoites reappeared in the blood in from seven to fourteen days, but no febrile relapse occurred in from five to eight weeks.

In these cases quinine hydrochloride grains 10 orally for periods ranging from two to nine consecutive days either failed to cause the disappearance of trophozoites from the blood, or failed to prevent their reappearance within a few days. The fact that owing to the variation in the ages of the patients the relative doses were different does not appear to have affected the result.

Group B

Quinine sulphate grains 10 orally were given in four cases (Nos. 9 to 12); the treatment being continued for four, six, twelve, and thirteen consecutive days respectively. In another case (No. 13) quinine sulphate grains $7\frac{1}{2}$ orally were given for fifteen days. The ages of the children varied from four months to four years. The results of these treatments are recorded in Table II.

In three of the cases treatment was begun during an apyrexial period, but all three had had fever the previous day. In the remaining two cases the temperature fell to normal in one day.

In one case (No. 12) trophozoites were present throughout; on the fourteenth day the treatment was abandoned. In the remaining four cases trophozoites disappeared from the cutaneous blood, in two cases in two days, in one case in ten or eleven days, and in one case the examinations were too infrequent to give an exact figure. None of the patients had attacks of fever during the treatments.

Relapses. In one case trophozoites did not disappear from the cutaneous blood. One of the remaining four cases did not relapse in an after-treatment observation period of seventy-two days. In the other three cases trophozoites reappeared in the blood within

TABLE II.

Summary of results of oral administration of quinine sulphate grains 10 to native children in malignant tertian malaria.

Number of case	Age in years	Date of end of treatment	Number of days on which treatment was given	Temperature fell to normal in — days after first dose	Trophozoites disappeared from cutaneous bood in — days after first dose	Trophozoite relapse occurred in — days after last dose	Febrile relapse occurred in — days after last dose	Observation period (in days) in case which did not relapse	Remarks
9	4/12	14.7.19	4	Apyrexia	2	...	...	72	
10	3	18.8.19	6	Apyrexia	2	3–12	15	...	
11	3	29.7.19	12	Apyrexia	10–11	9–15	14	...	
12	2	30.7.19	13	1	Present throughout	...	...	...	No fever. Treatment changed after 13 days.
13*	4	8.7.19	15	1	1–9	1–10	...	...	Quinine administered on the 11th day.

* The dose in this case was 7½ grains.

fifteen days, and a febrile relapse occurred about the same time in two of them, the third case being again treated with quinine as soon as parasites reappeared.

The action of quinine sulphate in these cases appeared to be similar to the action of quinine hydrochloride in Group A.

GROUP C

Quinine sulphate grains 20 orally were given in four cases (Nos. 14 to 17); the treatment being continued for five, nine, fifteen, and seventeen consecutive days respectively. The ages of the children varied from seven months to three years. The results of these treatments are recorded in Table III.

In all the cases treatment was begun during an apyrexial period. In one case (No. 17) trophozoites were present throughout; the

treatment was abandoned on the eighteenth day. In the remaining three cases trophozoites disappeared from the cutaneous blood in two, six or seven, and twelve days respectively. None of the patients had attacks of fever during the treatments.

Relapses. In one case trophozoites did not disappear from the cutaneous blood. In the three remaining cases trophozoites

TABLE III.

Summary of results of oral administration of quinine sulphate grains 20 to native children in malignant tertian malaria.

Number of case	Age in years	Date of end of treatment	Number of days on which treatment was given	Trophozoites disappeared from cutaneous blood in — days after first dose	Tropozoite relapse occurred in — days after last dose	Febrile relapse occurred in — days after last dose	Remarks
14	3	4.7.19	5	2	6–12	11	
15	2	8.7.19	9	6–7	1–8	9	
16	3	14.7.19	15	12	3–9	...	No febrile relapse in a 72 days' after-treatment observation period. Parasites persisted.
17	7/12	16.7.19	17	Present throughout	...	...	No fever. After 17 days an intramuscular injection of quinine bihydrochloride grains 3 was given, blood negative next day; relapses, parasitic on 8–13th day, febrile on 13th day after injection.

reappeared in the blood within twelve days; two of these cases had febrile relapses, on the ninth and eleventh days respectively, and one did not have a febrile relapse within an after-treatment observation period of seventy-two days.

It was our intention in these cases to give the quinine sulphate daily until the trophozoites disappeared from the blood, but as in the previous groups we found that in some patients quinine seemed to have little or no action on the parasites. Case No. 17 is remarkable in this respect. This child, only seven months old, took 20 grains of quinine daily for seventeen days, and, although the general condition of the child improved, at the end of this time the

parasites in the blood were as numerous as at the beginning. No vomiting and no other ill-effects were caused by the treatment. How much of the quinine was absorbed in this case, and in other similar cases, we do not know, but the parasites disappeared from the cutaneous blood within twenty-four hours after an intra-muscular injection of 3 grains of quinine bihydrochloride.

GROUP D

A mixture containing quinine hydrochloride grains 10 and liquor arsenici hydrochloridi minims 5 was given daily in five cases (Nos. 18 to 22), half the dose being given in the morning and half in the evening. In four of the cases the treatment was given for eight days; in the remaining case for only seven, because on the first day quinine sulphate grains 10 had been given in error. All the five children had been previously treated with quinine alone (see Table I), and had failed to go negative. The ages of the children varied from seven months to five years. The results of this treatment are recorded in Table IV.

TABLE IV.

Summary of results of oral administration of quinine and arsenic to native children in malignant tertian malaria

Number of case	Age in years	Date of end of treatment	Number of days on which treatment was given	Trophozoites disappeared from cutaneous blood in — days after first dose	Trophozoite relapse occurred in — days after last dose	Febrile relapse occurred in — days after last dose	After-treatment observation period (in days)	Remarks
18	7/12	20.8.19	8	Present throughout	...	...	35	No fever.
19	9/12	20.8.19	8	4	...	...	15	Lost sight of after the 15th day.
20	2	20.8.19	7*	Present throughout	...	29	35	A single febrile attack on the 29th day.
21	4	20.8.19	8	5	11–15	...	35	No febrile relapse in five weeks
22	5	20.8.19	8	3	22–28	...	35	No febrile relapse in five weeks.

* Because on the first day quinine sulphate 10 grains was given by mistake.

In all the cases treatment was begun during an apyrexial period: in one case (No. 20) there had been fever on the previous day, but in the other four there had been no recent attacks of fever.

In two cases trophozoites were present throughout; in the remaining three cases trophozoites disappeared from the cutaneous blood in three, four, and five days respectively.

None of the patients experienced fever during treatment.

Relapses. In two cases trophozoites did not disappear from the cutaneous blood; both cases continued to show parasites to the end of the after-treatment observation period, which in this group was only thirty-five days; one case had no febrile relapse, the other (No. 20) had a single febrile attack, on the twenty-ninth day. One case (No. 19) was lost sight of fifteen days after the cessation of treatment: up to this time neither parasitic nor febrile relapse had occurred. In the remaining two cases trophozoites reappeared in the blood within a month; neither case had a febrile relapse within an after-treatment observation period of thirty-five days.

Quinine and arsenic treatment in the doses given, although it effected the disappearance of the parasites from the blood in three out of five cases which had previously resisted quinine alone, cannot be said to have had a more beneficial action than the treatments given in the earlier groups.

GROUP E (CONTROL)

It was not possible to exclude the chance of reinfection in the cases under observation after treatment. As a matter of fact, no rain fell during the period occupied by this investigation, and all mosquitoes, but especially Anophelines, were uncommon.

As a control we treated with quinine six children (Nos. 23 to 28), all under one year old, in whose blood malaria parasites were not found. Each child received quinine hydrochloride grains 10 orally for two consecutive days, the treatments being given between the 28th and 31st of July.

These children and those comprised in Groups A, B, C, and D lived in the same locality and under similar conditions, and were examined in the same manner.

During an observation period of two months none of these six children showed evidence of malarial infection.

The results of the Malaria Investigation carried out at the Liverpool School of Tropical Medicine from 1917 to 1919 showed that, in simple tertian malaria, the percentage of relapses were similar after a large number of different short quinine treatments. A similar series of observations on malignant tertian malaria was not made, but it was found that in this disease after intra-muscular injections of quinine bihydrochloride grains 15 on each of two consecutive days only all the cases relapsed (1919, A), and that no better results followed the same treatment when reinforced by an intravenous injection of novarsenobillon, or extended into a course of liquor arsenicalis minims 30 by the mouth for sixteen days and quinine bihydrochloride grains 15 intra-muscularly on the first and second, eighth and ninth, fifteenth and sixteenth days (1919, B).

It may be permissible, therefore, to consider the seventeen cases included in Groups A, B, and C as forming a single series of malignant tertian malaria infections in young children treated by short courses of quinine. Of the seventeen cases, sixteen (equal to 94 per cent.) either did not become negative at all, or had a parasitic relapse. Of the nine cases which became negative and subsequently had a parasitic relapse four had also a febrile relapse, and two which did not relapse were observed for less than sixty days.

The results in the children who were under five years of age may be separately recorded for comparison with those in school boys from five to eighteen years of age presently to be considered. Fifteen of the children were under five years of age: of these fourteen (equal to 93 per cent.) either did not become negative at all (six), or had a parasitic relapse (eight). Of the eight cases which became negative and subsequently had a parasitic relapse four had also a febrile relapse, and two which did not relapse were observed for less than sixty days.

The following facts may also be briefly noted. The native children took quinine hydrochloride grains 10, and quinine sulphate grains 10 or 20 without ill-effects. These doses brought the temperature down to normal in those cases suffering from fever, and prevented febrile attacks occurring during treatment. It may be thought that the doses given were excessive, and liable to cause injurious effects, among which gastro-intestinal disturbance leading to non-absorption might be one. Children, however, are known to

stand well relatively large doses of quinine; and as has already been stated, no ill-effects were observed in these cases. It is hardly necessary to say that before starting observations on the action of such large doses we had tried smaller ones.

In seven of the seventeen cases parasites persisted in the blood notwithstanding treatment. This fact emphasises the absolute necessity of blood examinations as a control in rational treatment of malaria, for it can scarcely be questioned that it is the presence of the parasites, not the occurrence of fever, that is the actual and potential danger in malaria. We do not know to what extent the failure was due to failure to absorb the quinine, but we do not think that it would be practicable to treat very young children with intramuscular injections, and we are convinced that any treatment for malaria in such subjects must be oral if it is to be favourably received by the patients themselves, their parents, and their physicians.

One other point of some importance is the fact illustrated by several of our cases (for example Nos. 1, 2, 5, 16, 18, 21, 22), namely, that native children may have malaria parasites in the blood *abundantly* for many consecutive weeks without being troubled by febrile attacks.

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II.—ORAL ADMINISTRATION OF QUININE SULPHATE GRAINS 20 TO ADULT NATIVES INFECTED WITH MALIGNANT TERTIAN MALARIA

BY

J. W. S. MACFIE

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Quinine sulphate grains 20 orally were given to eleven adult native men (Nos. 29 to 39) infected with malignant tertian malaria. All the cases were infected in the Gold Coast. The observations were made at Accra during July, 1919, and were undertaken for comparison with observations being made at the same time on the effects of oral administration of quinine to young native children.

In every instance a diagnosis of malignant tertian malaria was made microscopically, and in all cases trophozoites were present in the blood on the day treatment was begun. Blood examinations of ordinary thin films were made daily until the parasites disappeared, and thereafter once a week during an after-treatment observation period of two months. In the table, in the Remarks column, the days referred to are days of the after-treatment observation period.

The patients were not admitted to hospital, and continued to go about as usual; eight of the cases (Nos. 30 to 37), however, were inmates of the Accra asylum, and so were under constant observation. Temperature charts were not kept, but the patients and their guardians were instructed to report at once any occurrence of illness or fever.

The quinine was administered by the mouth, in solution.

It was our intention to give this treatment daily until the trophozoites disappeared from the cutaneous blood: this was done in nine cases, seven receiving treatment on two consecutive days, and two on three days, but inadvertently two cases received treatment for longer periods, namely, five and six days respectively. The results of these treatments are recorded in the table.

In one case (No. 39) the temperature fell to normal in one day. In the other cases treatment was begun during an apyrexial period.

In all the cases trophozoites disappeared from the cutaneous blood in one to two days.

Relapses. No parasitic or febrile relapses were observed during the after-treatment observation period of sixty to sixty-four days. In one case (No. 33) the observation period was less than sixty days, namely, thirty-three days.

TABLE —

Summary of results of oral administration of quinine sulphate grains 20, to adult natives in Malignant Tertian Malaria.

Number of case	Date of end of treatment	Number of consecutive days on which treatment was given	Tropho-zoites disappeared from cutaneous blood in — days after first dose	Tropho-zoite relapse occurred in — days after last dose	Febrile relapse occurred in — days after last dose	After-treatment observa-ton period (in days) in cases which did not relapse	Remarks
29	22.7.19	2	1	...	...	64	
30	25.7.19	2	1	...	...	61	
31	25.7.19	2	1	...	...	61	
32	25.7.19	2	1	...	...	61	Crescents found on the 1st, 6th and 18th days.
33	25.7.19	2	1	...	...	33	
34	25.7.19	2	1	...	...	61	
35	25.7.19	2	1	...	...	61	
36	26.7.19	3	2	...	...	60	Crescents found on the 60th day.
37	26.7.19	3	2	...	...	60	
38	28.7.19	5	2	...	...	60	
39	10.7.19	6	1	...	...	62	

If it is permissible to group these eleven cases together as short treatments with quinine sulphate grains 20 of cases of malignant tertian malaria in adult natives, the percentage of parasitic relapses would be: minimum 0, maximum 9.

These results should be compared with those of Group C of the previous paper (see p. 86); they should also be compared with the results of the treatment of malignant tertian malaria with intramuscular injections of quinine, with or without the addition of arsenic, in Europeans in Liverpool (1919).

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III.—ORAL ADMINISTRATION OF QUININE SULPHATE GRAINS 10 DAILY FOR TWO CONSECUTIVE DAYS ONLY TO NATIVE SCHOOL-BOYS INFECTED WITH MALIGNANT TERTIAN MALARIA

BY

J. W. S. MACFIE

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The observations recorded in the two previous papers showed that there was a marked difference between native children and adults infected with malignant tertian malaria in their response to short quinine treatments. In the latter the parasites rapidly disappeared from the cutaneous blood, and neither parasitic nor febrile relapses were observed within an after-treatment observation period of two months. In the former the parasites frequently persisted in the cutaneous blood, and of those that became negative almost all had a parasitic relapse, and about one-half a febrile relapse also.

With a view to obtaining further information on this matter, permission was granted to examine a number of boys attending schools in Accra and to treat with quinine those found to be infected with malaria. All the boys who were thus examined and treated were volunteers. I have to thank Mr. J. Dewhurst, of the Gold Coast Education Department, for the interest he took in the investigation, without which it would not have been possible to carry out the observations, and Dr. M. W. Fraser for much assistance in collecting the blood films at the beginning of the work. But for the fact that other duties intervened, Dr. Fraser and I had hoped tc carry out these and other observations on malaria together, and I deeply regret that our work came to an untimely end.

As in the two previous papers, all the observations were made at

Accra, in the Gold Coast, West Africa. They were started on the 9th September, 1919, and ended on the 19th December, 1919; the dates on which the treatments ended are given in the text.

All the subjects were native school boys infected in the Gold Coast. In every instance a diagnosis of malignant tertian malaria was made microscopically, and in all cases trophozoites were present in the blood on the day treatment was begun. Excepting when otherwise indicated in the tables, blood examinations were made daily until the parasites disappeared from the cutaneous blood, and thereafter once a week during an after-treatment observation period of two months, the final (ninth) examination being made on or immediately after the sixtieth day. In the tables, in the Remarks columns, the days referred to are days of the after-treatment observation period.

All the boys appeared to be healthy. The fact that they were infected with malaria was only discovered by blood examination. During the observations they lived at their own homes, continued to attend school, and went about as usual.

Temperature charts were not kept. The boys were questioned as to the occurrence of illness or fever. In the case of the older boys this method of obtaining information was probably satisfactory, but in the case of the young boys it was not. In order to obtain some idea of the amount of illness caused by the infections, and the number of relapses, resort was had to the daily attendance register at the schools. This evidence is of a rather negative character: that is, if the attendance was regular it may be assumed that the boy was not ill, but if irregular the conclusion is less certain because there were many causes of absence besides illness, and mere lateness of arrival was accounted as absence. Such as it is, however, this evidence is of some value, because the attendances were very regular and clearly indicated that little serious illness troubled the boys.

The ages of natives in West Africa are seldom accurately known. The school boys on whom observations were made were arranged by their teachers in four age-groups, as follows:—Group A, 15 to 18; Group B, 12 to 14; Group C, 9 to 11; and Group D, 5 to 8 years. The treatment given to each case was the same, namely, quinine sulphate grains 10 orally on each of two consecutive days only. The quinine was given in solution.

In the tables, which summarised the results observed, the following symbols are used:—

— = No malaria parasites found.
t = Malignant tertian trophozoites found.
c = Malignant tertian gametes (crescents) found.
T = Quartan trophozoites found.
G = Quartan gametes found.

As it was not possible to exclude the chance of reinfection of the cases under observation after treatment, a few boys in whose blood parasites were not found were used as controls. These boys were given the same dose of quinine, and were examined in exactly the same manner as the others.

GROUP A (ages 15 to 18 years)

Eleven boys (Nos. 40 to 50) in this age-group were treated. The date of the end of treatment was the 11th of September, 1919. The eight weekly examinations were made on the seventh, fourteenth, twenty-first, twenty-ninth, thirty-fifth, forty-second, forty-ninth and fifty-sixth days after the cessation of treatment, and the final examination on the sixtieth day: occasionally, for unavoidable reasons, a blood examination had to be made a day or two late in one or two individuals. Six negative cases (Nos. 51 to 56) were used as controls: they received the same treatment and were examined on the same days as the other boys. The results are recorded in Table I.

In all the cases treatment was begun during an apyrexial period.

Trophozoites disappeared from the cutaneous blood either on the day treatment was begun or in one to two days.

Relapses. Seven of the eleven cases (64 per cent.) had parasitic relapses within the observation period. In them the parasites were found rather irregularly as shown in the table, and only one case (No. 47) admitted having had a febrile relapse. The regular attendance at school of the others, and their healthy appearance, was not suggestive of any considerable amount of illness, and the boys themselves stated that they had not suffered from fever.

None of the six control cases showed evidence of malaria during the observation period, and the attendance at school of all of them was regular throughout.

TABLE I.

Group A: School boys, 15 to 18 years.

Number of case	Trophozoites disappeared from cutaneous blood in — days after first dose	Results of blood examinations									Trophozoite relapse occurred in — days after last dose	Febrile relapse reported in — days after last dose	Observation period (in days)	Attendance at school during the observation period and other remarks
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th				
40	Same day	—	—	—	—	—	—	—	—	—	...	...	60	Attendance regular throughout.
41	1	—	—	—	t	t	t	—	—	—	22–29	No febrile relapse in 60 days	60	Attendance regular throughout
42	2	...	t	—	t	t	—	—	—	t	1–14	No febrile relapse in 60 days	60	Absent on the 6th, 7th and 8th days owing to toothache; otherwise attendance regular
43	1	—	—	—	—	—	—	—	—	—	...	...	60	Attendance regular throughout.
44	1	—	—	—	t	—	—	—	—	—	22–29	No febrile relapse in 60 days	60	Attendance regular throughout.
45	1	—	—	—	t	—	—	—	t	t	22–29	No febrile relapse in 60 days	60	Absent on the 39th day, owing to headache; otherwise attendance regular.
46	1	—	—	—	—	t	t	—	—	—	30–35	No febrile relapse in 60 days	60	Attendance regular throughout.
47	2	—	t	—	—	—	t	—	—	—	8–14	15	60	Absent on the 15th and 43rd days owing to fever; otherwise attendance regular.
48	2	—	—	—	—	—	—	t	—	—	43–49	No febrile relapse in 60 days	60	Absent on the 40th day, but not owing to illness; otherwise attendance regular.
49	1	—	—	—	—	—	—	—	—	—	...	...	60	Attendance regular throughout.
50	1	—	—	—	—	—	—	—	—	—	...	...	63	Attendance regular throughout.
51 to 56	Six control cases	—	—	—	—	—	—	—	—	—	...	...	60	Attendance of all six regular throughout.

GROUP B (ages 12 to 14 years)

Nineteen boys (Nos. 57 to 75) in this age-group were treated. The date of the end of treatment was the 17th of September, 1919. The eight weekly examinations were made on the ninth, sixteenth, twenty-first, thirtieth, thirty-seventh, forty-fourth, fifty-first, and fifty-seventh days after the cessation of treatment, and the final examination on the sixty-first day: on one occasion, owing to absence on the proper day, an examination had to be made a day late. Two negative cases (Nos. 76 and 77) were used as controls: they received the same treatment and were examined in the same manner as the other boys. The results are recorded in Table II.

In all the cases treatment was begun during an apyrexial period.

Trophozoites disappeared from the cutaneous blood in from one to two days.

Relapses. Seventeen of the nineteen cases (89 per cent.) had parasitic relapses within the observation period. In them the parasites were found rather irregularly as shown in the table, and so far as could be ascertained, no single case had a febrile relapse. The regularity of attendance at school of most of the boys, and their healthy appearance, certainly did not suggest that much illness was caused by the malaria infections, and in fact none of the boys admitted having been ill.

Neither of the two control cases showed evidence of malaria during the period they were under observation.

GROUP C (ages 9 to 11 years)

Thirteen boys (Nos. 78 to 90) in this age-group were treated. The date of the end of treatment was the 23rd of September, 1919. The eight weekly examinations were made on the eighth, fifteenth, twenty-second, twenty-ninth, thirty-seventh, forty-fourth, fifty-first, and fifty-seventh days after the cessation of treatment, and the final examination on the sixty-second day. Ten negative cases (Nos. 91 to 100) were used as controls: they received the same treatment and were examined in the same manner as the other boys. The results are recorded in Table III.

In all the cases treatment was begun during an apyrexial period.

Trophozoites disappeared from the cutaneous blood in from one to two days.

TABLE II. Group B. School boys, 12 to 14 years.

Number of case	Trophozoites disappeared from cutaneous blood in — days after first dose	Results of blood examinations									Trophozoite relapse occurred in — days after last dose	Febrile relapse reported in — days after last dose	Observation period (in days)	Attendance at school during the observation period and other remarks
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th				
57	1	—	—	t	—	—	t	—	—	—	17–21	No febrile relapse in 61 days	61	Attendance regular throughout.
58	1	—	—	—	—	t	—	t	t	—	31–37	No febrile relapse in 61 days	61	Attendance regular throughout.
59	1	—	—	—	—	t	—	—	c	—	31–37	No febrile relapse in 61 days	61	Attendance regular throughout.
60	1	—	—	—	—	—	—	—	—	—	...	...	61	Attendance regular throughout
61	1	—	—	t	t	t	—	—	—	—	17–21	No febrile relapse in 61 days	61	Attendance regular throughout.
62	1	—	—	—	—	—	t	—	c	...	38–44	No febrile relapse in 57 days	57	Absent on part of the 20th, 40th, and 47th days.
63	1	—	—	—	...	—	—	—	t	t	52–57	No febrile relapse in 61 days	61	Absent on the 15th, 30th and 41st days ; and on part of the 26th, 29th, 36th, and 49th days.
64	1	—	—	—	t	—	—	—	—	t	22–30	No febrile relapse in 61 days	61	Absent on the 5th and 33rd days ; and on part of the 37th day.
65	2	—	—	—	—	—	t	t	t	t	38–44	No febrile relapse in 61 days	61	Attendance regular throughout.
66	1	—	—	—	t	—	t	—	c	—	22–30	No febrile relapse in 61 days	61	Attendance regular throughout.
67	2	—	t	t	t	—	—	t	t	t	10–16	No febrile relapse in 61 days	61	Attendance regular throughout.
68	2	—	—	t	t	—	—	t	—	—	17–21	No febrile relapse in 61 days	61	Absent on part of the 19th, 36th, 40th and 43rd days.
69	1	—	—	—	—	—	—	—	t	t	52–57	No febrile relapse in 61 days	61	Attendance regular throughout.
70	2	—	—	t	t	—	t	—	—	c	17–21	No febrile relapse in 61 days	61	Attendance regular throughout.
71	2	—	—	t	—	t	—	—	—	—	17–21	No febrile relapse in 61 days	61	Absent on part of the 47th and 50th days.
72	2	—	—	—	—	—	—	—	t	—	52–57	No febrile relapse in 61 days	61	Attendance regular throughout.
73	2	—	—	t	—	t	t	t	—	—	17–21	No febrile relapse in 61 days	61	Attendance regular throughout.
74	1	—	—	—	—	t	t	—	t	t	31–37	No febrile relapse in 61 days	61	Attendance regular throughout.
75	1	—	—	—	—	—	—	—	—	—	...	...	61	Absent on part of the 58th day.
76	Control	—	—	—	—	—	—	—	—	—	...	...	61	Absent on the 26th, 33rd and 47th days.
77	Control	—	—	—	—	...	—	—	—	—	...	...	61	Absent on the 43rd day ; and on part of the 1st, 2nd 8th, 13th, 15th, 23rd, 26th, 28th, 34th, 37th, 47th, 48th and 49th days.

TABLE III.

Group C. School boys, 9 to 11 years.

Number of case	Trophozoites disappeared from cutaneous blood in — days after first dose	Results of blood examinations									Trophozoite relapse occurred in — days after last dose	Febrile relapse reported in — days after last dose	Observation period (in days)	Attendance at school during the observation period and other remarks
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th				
78	2	—	—	—	—	...	—	—	—	—	...	...	62	Absent on the 28th day; and on the 35th, 37th and part of the 38th days, ill with 'stomach.'
79	2	—	—	—	—	t	—	—	—	—	30–37	No febrile relapse in 62 days	62	Absent on part of the 28th and 59th days.
80	1	—	—	—	t	—	—	—	—	—	23–29	No febrile relapse in 62 days	62	Absent on part of the 8th, 9th and 36th days.
81	1	—	—	—	t	—	t	—	—	—	23–29	No febrile relapse in 62 days	62	Attendance regular throughout.
82	1	—	—	—	t	—	t	—	—	—	23–29	No febrile relapse in 62 days	62	Attendance regular throughout.
83	1	—	—	—	—	—	—	—	—	t	58-62	No febrile relapse in 62 days	62	Absent on the 20th day; and on part of the 41st day.
84	2	—	—	—	—	t	t	c	—	—	30–37	No febrile relapse in 62 days	62	Attendance regular throughout.
85	2	—	...	—	—	—	—	—	—	—	...	...	62	Absent on the 41st day; and on the 15th and part of the 14th and 17th days with 'headache.'
86	1	—	—	—	—	—	—	...	...	...	...	...	44	Absent on the 24th, 31st, 36th, 38th, 42nd and 43rd days; and on part of the 7th, 15th, 16th, 23rd and 41st days. Left the school.
87	1	—	—	—	t	t	—	t	t	t	23–29	No febrile relapse in 62 days	62	Attendance regular throughout.
88	1	—	—	—	—	—	—	—	—	—	...	...	62	Attendance regular throughout.
89	2	—	—	—	t	—	—	—	t	t	23–29	No febrile relapse in 62 days	62	Attendance regular throughout.

TABLE III—*continued.*

Number of case	Trophozoites disappeared from cutaneous blood in — days after first dose	Results of blood examinations									Trophozoite relapse occurred in — days after last dose	Febrile relapse reported in — days after last dose	Observation period (in days)	Attendance at school during the observation period and other remarks
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th				
90	1	—	—	—	—	—	—	—	—	—	...	...	62	Absent on the 23rd and 24th days attending court; and on part of the 17th, 28th, 36th and 41st days.
91	Control	—	—	—	—	—	—	t	t	—	45–51	No febrile relapse in 62 days	62	Absent on part of the 23rd and 30th days.
92	Control	—	—	—	—	—	—	—	—	—	...	...	62	Attendance regular throughout.
93	Control	—	—	—	—	—	—	—	—	—	...	...	62	Absent on the 13th day.
94	Control	—	—	—	—	—	—	—	—	—	...	...	62	Attendance regular throughout.
95	Control	—	—	—	—	—	—	—	—	—	...	...	62	Attendance regular throughout.
96	Control	—	—	—	—	—	—	—	—	—	...	...	62	Absent on the 13th and 14th days owing to a death in the family.
97	Control	—	—	—	—	—	—	—	—	—	...	...	62	Absent on the 10th day; and on part of the 6th, 36th and 56th days.
98	Control	—	—	—	—	—	—	—	—	—	...	...	62	Absent on the 35th and 41st days; and on part of the 50th day.
99	Control	—	—	—	—	t	t	t	—	—	30–37	No febrile relapse in 62 days	62	Attendance regular throughout.
100	Control	—	—	—	T	T.G.	T.G.	—	—	—	23–29	No febrile relapse in 62 days	62	Attendance regular throughout.

Relapses. Seven of the thirteen cases had parasitic relapses within a sixty-day observation period; one was only found to have relapsed at the last examination, so that he may or may not have relapsed within sixty days; and one was observed for less than sixty days, namely, for forty-four days. The number of parasitic relapses within a sixty-day observation period may, therefore, have been from seven to nine, and the percentage from 54 to 69. In those cases which relapsed parasites were found with considerable irregularity, as is shown in the table. So far as could be ascertained, none of the cases had febrile relapses: illness was denied by the boys, and their attendance at school was on the whole regular, and certainly not less regular than the attendance of the boys who did not relapse.

Two of the ten control cases (20 per cent.) showed parasites of malignant tertian malaria, and one quartan parasites during the observation period. A proportion of the relapses referred to above may therefore have been reinfections, but it should be remembered that the examinations of relapse cases has shown that parasites may not be found in the cutaneous blood during several consecutive weeks.

GROUP D (ages 5 to 8 years)

Nineteen boys (Nos. 101 to 119) in this age-group were treated. The date of the end of treatment was the 28th of October, 1919. Owing to an unfortunate delay in obtaining permission to examine these small boys the Christmas holidays intervened before the expiration of the after-treatment observation period. Seven weekly examinations were, however, made, namely, on the eighth, fifteenth, twenty-second, twenty-ninth, thirty-sixth, forty-third, and fiftieth days after the cessation of treatment: on a few occasions, for unavoidable reasons, the blood examinations of one or two individuals had to be made a day late. Seven negative cases (Nos. 120 to 126) were used as controls: they received the same treatment and were examined in the same manner as the other boys. The results are recorded in Table IV.

In all the cases treatment was begun during an apyrexial period.

Trophozoites disappeared from the cutaneous blood in from one to two days.

Relapses. Twelve of the nineteen cases (63 per cent.) had

TABLE IV.

Group D. School boys, 5 to 8 years.

Number of case	Trophozoites disappeared from cutaneous blood in — days after first dose	Results of blood examinations							Trophozoite relapse occurred in — days after last dose	Febrile relapse reported in — days after last dose	Observation period (in days)	Attendance at school during the observation period. Absent on part of the day at least on the following days :—
		1st	2nd	3rd	4th	5th	6th	7th				
101	2	—	—	—	—	—	—	—	...	No febrile relapse reported.	50	6th, 24th, 27th, 28th and 34th.
102	1	—	—	—	—	—	—	—	...		50	Attendance regular throughout
103	1	—	—	—	—	t	—	—	31–36		50	8th, 9th and 22nd.
104	1	—	...	—	—	t	t	—	30–36		50	6th, 15th, 34th, 35th and 43rd.
105	2	—	—	—	t	t	t	t	23–29		50	30th, 31st, 44th, 45th and 48th
106	1	—	—	—	—	—	—	t	44–50		50	15th and 24th.
107	1	—	—	—	—	t	t	—	30–36		50	6th, 7th, 8th, 9th, 15th and 20
108	1	—	—	t	t	t	t	—	16–22		50	6th, 7th, 8th, 9th, 22nd and 28
109	2	—	—	—	—	—	—	—	...		50	6th, 7th and 29th.
110	1	—	—	—	...	—	t	t	37–43		50	10th, 34th and 35th.
111	2	—	—	—	—	—	—	—	...		50	8th, 9th and 48th.
112	1	—	—	—	—	—	—	—	...		51	6th and 22nd.
113	2	—	t	t	t	t	t	t	9–15		50	Attendance regular throughout
114	2	—	—	t	t	—	—	t	16–22		50	41st and 42nd.
115	1	—	—	—	t	...	—	—	23–29		51	6th, 21st and 34th.
116	1	—	—	—	—	—	...	—	...		51	7th, 8th, 9th, 10th, 13th, 17t 22nd, 23rd, 24th, 27th, 29t 30th and 34th.
117	2	—	—	—	t	t	—	t	23–29		50	6th, 7th and 21st.
118	1	—	—	—	t	t	—	—	23–30		50	22nd and 34th.
119	2	—	—	—	—	...	—	...	...		43	6th, 16th, 27th, 28th, 29th, 34t 35th and 36th.
120	Control	—	—	—	t	t	—	—	23–29	No febrile relapse reported.	50	14th and 27th.
121	Control	—	—	—	—	—	—	—	...		50	6th.
122	Control	—	—	—	—	—	—	—	...		50	Attendance regular throughout
123	Control	—	—	—	—	—	—	—	...		50	6th.
124	Control	—	—	—	—	—	—	—	...		50	6th and 7th.
125	Control	—	—	—	—	—	—	—	...		50	6th, 22nd, 27th, 29th and 34th
126	Control	—	—	—	—	—	—	—	...		50	6th, 9th, 20th, 24th, 28th, 29 and 34th.

parasitic relapses within the fifty-day observation period. In most of them the parasites were found irregularly, as is shown in the table. No reports of fever were received, but clearly very little reliance can be placed on the statements of young boys with regard to a matter such as the occurrence of febrile relapses. The attendance at school of such children was also not unnaturally rather irregular; there were 'epidemics' of absenteeism on certain days, and unpunctuality, with the penalty of being marked absent, was common. In the table are shown the days on which each child was marked absent during the observation period; the average numbers of absences were as follows: in cases which relapsed 3·9, in cases which did not relapse 2·6 days. This may be considered as indicating at any rate some degree of invalidity as the accompaniment of malaria infection. It will be noted, however, that the boy who was most frequently absent (No. 116) did not relapse, and that the boy who most consistently showed parasites in his blood (No. 113) was never absent.

One of the seven control cases (14 per cent.) showed malignant tertian malaria parasites during the observation period.

It should be repeated that the results in this Group are only comparable with those obtained in Groups A, B, and C up to the seventh weekly examination. In the latter Groups, taken together, twenty-eight out of the thirty-two relapses occurred during this part of the observation period. At the same rate the relapses in Group D during an observation period of sixty days should have equalled 72 per cent. This figure is a purely hypothetical one.

Cases which received half the treatment only

Eight boys (Nos. 127 to 134) belonging to the above age-groups received for one reason or another only half the standard treatment; that is, to each a single dose of quinine sulphate grains 10 was administered. The results of this abbreviated treatment are recorded in Table V.

In all the cases treatment was begun during an apyrexial period.

In one case trophozoites did not disappear from the cutaneous blood; in six they disappeared in one to two days, and in one in two to nine days.

Relapses. In one case trophozoites did not disappear from the

TABLE V.

Cases which received half the treatment.

Number of case	Group	Trophozoites disappeared from cutaneous blood in — days after first dose	Results of blood examinations									Trophozoite relapse occurred in — days after last dose	Febrile relapse reported in — days after last dose	Observation period (in days)
			1st	2nd	3rd	4th	5th	6th	7th	8th	9th			
127	B	Present throughout	t	t	t	t	t	t	...	t	t	Present throughout	...	62
128	B	2–9	—	—	—	t	—	—	t	t	t	22–30	...	61
129	B	1–2	—	—	...	—	—	t	t	—	—	39–45	...	62
130	B	1–2	—	—	—	...	—	—	—	—	—	...	...	62
131	C	1–2	t	—	—	—	—	—	t	—	—	3–9	...	63
132	C	1–2	—	—	t	t	—	—	—	—	—	17–23	...	64
133	D	1–2	t	t	...	...	t	t	—	...	...	3–10	...	51
134	D	1–2	—	—	t	...	...	...	...	...	...	17–24	...	24

cutaneous blood; in six of the remaining seven cases there was a parasitic relapse, in two as early as the first weekly examination. The treatment, therefore, either failed to cause the parasites to disappear or to prevent a relapse in seven out of eight cases (87·5 per cent.).

So far as could be ascertained, no febrile relapse occurred in any case.

SUMMARY AND CONCLUSION

Quinine sulphate grains 10 orally for two consecutive days only were given to sixty-two native school boys at Accra whose ages ranged from five to eighteen years. All the boys appeared to be healthy, and were found to be infected with malignant tertian malaria by blood examination.

This dose of quinine was sufficient in every case to cause the disappearance of the parasites from the cutaneous blood in one to two days.

After this treatment parasites reappeared in the blood in the majority of cases (see Table VI). The percentage of parasitic relapses was highest in the age-group comprising boys of twelve to fourteen years. In the absence of any other reason to account for this, it may be suggested that it was due to the critical period coincident with the advent of puberty.

TABLE VI.

Age groups (years)	Number of cases	Percentage which relapsed parasitically within an after-treatment observation period of	
		50 days	60 days
5–8	19	63	[72]
9–11	13	54–62	54–69
12–14	19	74	89
15–18	11	64	64

Only one of the sixty-two boys is definitely known to have had a febrile relapse; it is possible, however, that some of the youngest boys may have had malaria attacks that were not reported. From the regularity of attendance at school of the majority of the boys it is clear that the amount of illness accompanying the large number of parasitic relapses was very small.

Twenty-five boys in whose blood no parasites were found were used as controls; three showed malignant tertian parasites, and one quartan parasites during the observation periods.

These results should be compared with those following short quinine treatments administered to young native children and adult natives at Accra, and to adult Europeans at Liverpool. An exact comparison is not possible because the treatments were not identical, but it may be doubted if the differences were of a kind that would affect the incidence of parasitic and febrile relapses.

As regards the disappearance of the parasites from the blood, the native school boys responded to treatment in a manner similar to the adult natives and Europeans, but very different from the young native children.

The number of relapses, both parasitic and febrile, were less numerous than they were in the young native children or the adult Europeans, but more numerous than in the adult natives. The different results may, most naturally, be attributed to the development of a tolerance in the natives. It may at any rate be noted that the power of the native to cope with malaria infections begins to make itself felt early in life, has already attained a considerable degree of efficiency by the age of five to eight years, thereafter is maintained during adolescence with a remission at the age of puberty, and is enhanced in adult life.

The percentages of relapses, both parasitic and febrile, among the adult Europeans treated at Liverpool exceeded those among even young native children treated at Accra. This may have been due to an absence of or failure to develop tolerance on the part of the Europeans at Liverpool. It is possible, however, that another factor should be considered, namely, that malaria does not manifest itself in quite the same way in a temperate and a tropical climate.

In the course of the Liverpool Malaria Investigation, 1917-1919, it was found that, 'broadly speaking, a very small percentage of cures is obtained in the winter and spring and a comparatively high percentage in the summer and autumn,' and a graph was published showing that 'the higher the mean daily temperature the higher the percentage of cures.' At Liverpool the highest percentages of cures* were recorded during the months of July and August, when the mean daily temperature was about 60° F. In the tropics the mean daily temperature is high throughout the year, and it might, therefore, be anticipated that the percentage of cures would also be high. In Table VII are summarised the meteorological data recorded at Accra in the year 1919. If this factor is of importance its effects appear to be least during the first few years of life.

Unfortunately no corresponding series of observations could be carried out on Europeans at Accra. In a single case, infected between the 22nd and 27th of August, a malaria attack developed on the 6th of September, and malignant tertian parasites were found in the blood. Quinine hydrochloride grains 10 orally were taken

* The term 'cure' in this connexion signifies no parasitic relapse within an observation period of sixty days after the cessation of treatment.

daily from the 6th to the 9th of September, inclusive; the parasites disappeared from the cutaneous blood in one day, and no relapse, either parasitic or febrile, took place during an after-treatment observation period of sixty-nine days.

TABLE VII.

Meteorological data, Accra, 1919.

Meteorological records	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Average maximum shade temperature (°F.) ..	83·74	84·25	90·83	87·90	88·22	87·26	84·58	84·03	83·90	85·77	86·63	86·06
Average minimum shade temperature (°F.) ...	67·87	68·75	71·96	61·38	63·61	63·06	61·94	70·22	74·33	73·19	72·46	71·90
Rainfall in inches	0·09	1·82	0·54	4·82	7·52	1·99	...	...	0·44	2·42	0·8	...

REFERENCE

STEPHENS, J. W. W., YORKE, W., MACFIE, J. W. S., BLACKLOCK, B., COOPER, C. F., and CARTER, H. F. (1918). *Ann. Trop. Med. & Parasitol.*, Vol. XII, p. 208.

daily from the 6th to the 9th of September; thereafter the parasites disappeared from the circulating blood during days, and no relapse, either parasitic or febrile, took place during an after-treatment observational period of sixty-nine days.

[illegible]

IV—ORAL ADMINISTRATION OF QUININE SULPHATE TO NATIVES INFECTED WITH QUARTAN AND SIMPLE TERTIAN MALARIA

BY

J. W. S. MACFIE

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In the course of the observations on malignant tertian malaria already described, a few cases of quartan and simple tertian malaria were met with; the observations made on these cases are recorded in this paper.

As in the three previous papers, all the observations were made at Accra, in the Gold Coast, West Africa. The dates on which treatments ended are given in the tables. All the subjects were natives of West Africa infected in the Gold Coast. In every instance a diagnosis of the type of malaria was made microscopically, and in all cases trophozoites were present in the blood on the day treatment was begun. Blood examinations were made daily until the parasites disappeared from the cutaneous blood, and thereafter once a week during the after-treatment observation period. In the tables, in the Remarks columns, the days referred to are days of the after-treatment observation period.

All the subjects appeared to be healthy. The fact that they were infected with malaria was only discovered by blood examination. They lived at their own homes and went about as usual whilst under observation.

Temperature charts were not kept. The patients or their parents, however, were questioned as to attacks of fever or other illness, and in the case of school boys the attendance register was consulted.

The quinine sulphate was administered by the mouth, in solution.

QUARTAN MALARIA

Fifteen cases (Nos. 135 to 149) of quartan malaria were treated with quinine sulphate. Three of the cases received grains 20 on two, two, and nine consecutive days respectively, one received grains 10 on one day only; and the remaining eleven received grains 10 on two consecutive days. The cases ranged in age from six months to eighteen years, and included also one elderly man of sixty-five years. All the subjects excepting No. 147 were males. The results of these treatments are recorded in Table I.

TABLE I.

Summary of results of oral administration of quinine sulphate to natives in quartan malaria.

Number of case	Age (in years)	Date of end of treatment	Daily dose of quinine sulphate in grains	Number of consecutive days on which treatment was given	Temperature fell to normal in — days after first dose	Trophozoites disappeared from cutaneous blood in — days after first dose	Trophozoite relapse occurred in — days after last dose	Febrile relapse occurred in — days after last dose	After-treatment observation period (in days)	Remarks
135	65	25.7.19	20	2	Apyrexia	1	...	...	61	
136	18	11.9.19	10	2	Apyrexia	Same day	...	...	60	
137	17	11.9.19	10	2	Apyrexia	1	57–60	...	60	
138	14	17.9.19	10	2	Apyrexia	2	...	...	61	
139	13	17.9.19	10	2	Apyrexia	2	52–57	...	61	
140	12	17.9.19	10	2	Apyrexia	1	...	...	61	
141	12	17.9.19	10	1	Apyrexia	1	2–9	...	61	
142	11	23.9.19	10	2	Apyrexia	1	...	...	62	
143	10	23.9.19	10	2	Apyrexia	1	...	...	62	
144	8	28.10.19	10	2	Apyrexia	2	...	...	50	
145	6	28.10.19	10	2	Apyrexia	2	...	...	50	
146	5	28.10.19	10	2	Apyrexia	2	23–29	...	50	
147	2	8.7.19	20	9	Apyrexia	3	(21)	...	...	Oral administration of quinine sulphate grains 10, restarted on the ninth day and given daily; relapse occurred in spite of this.
148	1	1.7.19	20	2	Apyrexia	Same day	...	...	85	Fever on the 59th day; blood negative on the 60th day.
149	6/12	30.7.19	10	2	Apyrexia	3	8–14	...	56	

In all the cases treatment was begun during an apyrexial period.

Trophozoites disappeared from the cutaneous blood either on the day treatment was begun or in one to three days. None of the cases had fever during treatment.

Relapses. Six of the fifteen cases had parasitic relapses. In two cases which did not relapse (Nos. 144 and 145) the after-treatment observation period was less than sixty days, namely fifty days. The percentage of parasitic relapses was, therefore, minimum 40, maximum 53. The case to which only a single dose of quinine sulphate grains 10 was given relapsed at once. Two of the three children under five years of age relapsed within a month.

So far as could be ascertained, none of the cases had febrile relapses. In those cases which did not relapse parasitically the length of time each was under observation after the parasitic relapse can be calculated from the data given in the table.

SIMPLE TERTIAN MALARIA

Simple tertian malaria is uncommon at Accra, and during this investigation only five cases (Nos. 150 to 154) were identified. To three of these cases quinine sulphate grains 10 was administered on two consecutive days; to two quinine sulphate grains 20 on two and three consecutive days respectively. The ages of the subjects ranged from one year to thirty-five years; they were all males. The results of these treatments are recorded in Table II.

Table II.

Summary of results of oral administration of quinine sulphate to natives in simple tertian malaria.

Number of case	Age (in years)	Date of end of treatment	Daily dose of quinine sulphate in grains	Number of consecutive days on which treatment was given	Temperature fell to normal in — days after first dose	Trophozoites disappeared from cutaneous blood in — days after first dose	Trophozoite relapse occurred in — days after last dose	Febrile relapse occurred in — days after last dose	After-treatment observation period (in days)	Remarks
150	35	26.7.19	20	3	Apyrexia	2	...	...	60	
151	16	11.9.19	10	2	Apyrexia	1	36–42	...	60	
152	16	11.9.19	10	2	Apyrexia	1	...	...	60	
153	5	31.7.19	10	2	Apyrexia	Present throughout	...	...	...	No fever. Quinine and arsenic treatment started on the 12th day.
154	1	1.7.19	20	2	Apyrexia	Same day	...	...	85	

In all the cases treatment was begun during an apyrexial period. Trophozoites were present throughout in one case; in the other four they disappeared from the cutaneous blood either on the day treatment was begun or in one to two days. None of the cases had fever during treatment.

Relapses. In one case the trophozoites did not disappear from the cutaneous blood; this case was a young child. Of the remaining four cases one had a parasitic relapse, but no febrile relapse, within an after-treatment observation period of sixty days.

CONCLUSION

These observations, so far as they go, indicate that in quartan and simple tertian malaria, as in malignant tertian malaria, the percentage of relapses in natives other than very young children treated in the tropics is decidedly less than in Europeans treated in England.

ON THE RESULTS OBTAINED FROM SURVEYS FOR BREEDING-PLACES OF TREE-HOLE MOSQUITOES IN LIVERPOOL AND NEIGHBOURHOOD

BY

B. BLACKLOCK

AND

HENRY F. CARTER

(*Received for publication* 18 *May*, 1920)

PLATE I

With a view to determining the frequency with which breeding-places of *Anopheles plumbeus*, Steph., occur in trees, a series of surveys of the trees in certain areas has been made. Although the primary object of the work was to obtain such information regarding *A. plumbeus*, observations on *Ochlerotatus geniculatus*, Ol., are also recorded as the close association of these two species (*i.e.*, their coincident distribution and very similar breeding habits) renders the capture of larvae of the latter inevitable in such an investigation in this district.

METHOD OF CONDUCTING THE SURVEY

The work was performed during the months of March and April, 1920, in areas taken at random. No preference was given to localities in which breeding-places of *A. plumbeus* had previously been found; in fact, one area in which earlier work indicated exceptional abundance was excluded.

The method adopted in each survey was to examine systematically and consecutively every tree within the area chosen, provided that the diameter of the bole, at five feet from the ground, measured not less than, approximately, six inches. Except in five trees which were examined up to a height of thirty-two feet, our observations were limited to holes, or other places apparently capable of holding water, situated not more than twenty-five feet from the ground. From ground level it was often difficult to decide whether or not a definite hole existed at places where branches had been cut or broken

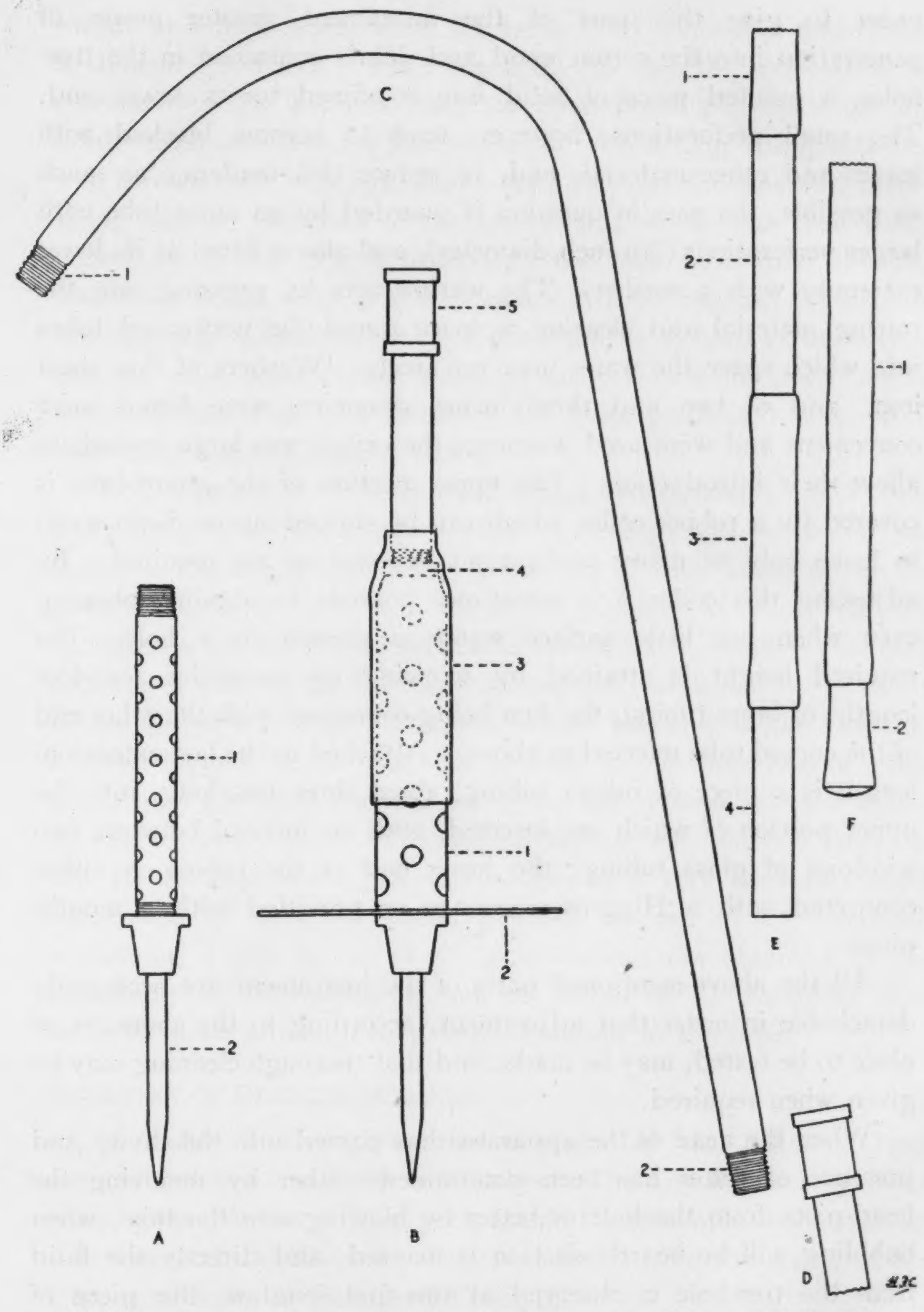
off high up on a tree. All places, therefore, where a cavity appeared to exist, and all forks and clefts where water might possibly lodge, were tested. After each examination in which a positive result was obtained by means of the apparatus described below, the instrument was thoroughly cleansed with water in order to exclude any possibility of larvae remaining in the tubes and being washed down when the next water-containing place was examined.

No correlation of breeding-places with acreage has been made, or is yet possible, owing to the irregular distribution of the areas surveyed.

Apparatus and Method of Use

The necessity for some special apparatus for the systematic examination of possible breeding-places of *A. plumbeus* was impressed upon us by our search for larvae during the summer of 1919. Cavities situated low down (not higher than six feet) can be examined, more or less successfully and rapidly, with a spoon or ladle, provided the orifice is sufficiently large; but for holes or forks at higher levels this method of examination, involving, as it does, climbing or the use of a ladder, is too exhausting and slow to be of practical value. By means of a siphoning apparatus, such as that shown in the figure, it is possible to draw off the water contained in holes situated at any height with comparative ease and rapidity. Such an instrument has further advantages over spoons and ladles particularly when detailed work is required. The head of the siphon can be introduced into apertures too small to admit a spoon, and, by attaching lengths of metal tubing, can be extended to the bottom of a cavity without difficulty. Moreover, when much water is present, the suction produced by siphoning draws into the apparatus numbers of larvae which would ordinarily escape capture with a spoon, the use of which continually disturbs the surface layers and causes the larvae to remain, for the most part, near the bottom.

The apparatus consists of a narrow copper tube curved at the top, with the last three inches of the curved portion perforated by numerous small holes ($\frac{1}{16}$th inch diameter). This perforated portion is separated from the rest of the tube and provided at both ends with threads which screw into suitable sockets. In



Apparatus for collecting tree-hole mosquito larvae. A, 1, inner perforated tube; 2, solid metal point. B, 1, outer perforated tube; 2, washer (3-inch diameter); 3, rubber collar; 4, socket into which the top of the inner tube screws; 5, socket for attachment to upper end (C 1) of curved tube. C, curved tube; 1, upper end; 2, lower end for attachment of extensions. D, head of first extension length. E, rubber tubing (1 and 3) provided with glass windows (2 and 4). F, rubber tubing (1) to which a mouth-piece (2) or a syringe is attached. (Reduced one-half).

order to give this part of the instrument greater power of penetration into the rotten wood and débris contained in the tree-holes, a pointed piece of solid iron is affixed to its lower end. The small perforations, however, tend to become blocked with leaves and other material, and, to reduce this tendency as much as possible, the part in question is guarded by an outer tube with larger perforations ($\frac{1}{8}$th inch diameter), and also is fitted at its lower extremity with a washer. The washer acts by pressing into the rotting material and clearing a space round the perforated tubes into which space the water may run freely. Washers of thin sheet iron, and of two and three inches diameter, were found most convenient and were used whenever the orifice was large enough to allow their introduction. The upper portion of the guard-tube is covered by a rubber collar which can be slipped up or down so as to leave only as many perforations exposed as are required. By adjusting this collar it is sometimes possible to obtain siphoning even when but little surface water is present in a hole. The required height is attained by screwing on successive four-foot lengths of brass tubing, the first being connected with the other end of the curved tube referred to above. Attached to the last extension-length is a piece of rubber tubing, about three feet long, into the upper portion of which are inserted, with an interval between, two windows of glass tubing; the lower end of the tubing is either connected with a Higginson syringe or provided with a mouth-piece.

All the above-mentioned parts of the instrument are necessarily detachable in order that adjustment, according to the character of place to be tested, may be made, and that thorough cleaning may be given when required.

When the head of the apparatus has passed into the cavity and presence of water has been determined—either by removing the head-piece from the hole or better by blowing into the tube, when bubbling will be heard—suction is exerted, and directly the fluid from the tree-hole is observed at the first window, the piece of rubber tubing immediately below it is compressed and the tube below the second window detached. The fluid is then run into a net fitted with a glass bottle.

The difficulties attending the use of this apparatus are not great

except in a high wind, when the tubes bend somewhat and render it difficult to direct. More especially is this the case when an extension to the head is used for deep holes situated high up. Under such conditions a leaden weight with a long string attached was thrown over a bough above the hole and the free end of the string tied to the head of the instrument, which was then easily pulled up to the neighbourhood of the hole. Another difficulty sometimes occurs when a hole in which little rotting has taken place contains only a small quantity of water and is so hard at the bottom that the solid point cannot penetrate; in this case the point can be removed, and with it if necessary the inner perforated tube, while the rubber collar is slipped down.

The apparatus has proved most satisfactory, and was particularly efficient in cases where a strong flow of water was obtained, the larvae then being drawn in, in large numbers, by the powerful suction. It has failed to siphon, however, on two occasions when water was present in considerable quantity; on each occasion a view of the hole was subsequently obtained by climbing or the aid of a ladder. The first failure was due to the fact that a water-logged bird's nest was present in the hole and a great quantity of glutinous material and grass were mixed with the water; no larvae were found. The second failure was partial, and was due to blockage of the perforated tubes by a very dense flocculent suspension of decayed wood; a small amount of the material, containing a few larvae of *O. geniculatus*, was obtained at the beginning of the operation, but no larvae of *A. plumbeus* were brought down although they were abundant in the hole.

Analyses of Results obtained

In Table I are given the numbers of the different trees encountered in each of the six surveys. The first four surveys were done in the suburbs of Liverpool, within the four-mile limit, number five was made at Knowsley Park, six miles from the centre of the city, number six at Delamere, Cheshire.

As regards the first group (surveys one to four), it will be noted that oaks form an insignificant proportion of the trees; in survey six—Delamere Forest—the most striking fact is the entire absence of elms, horse-chestnuts and sycamores, trees in which, as will be

seen later (Table III) breeding-places of *A. plumbeus* and *O. geniculatus* were most commonly found. It is necessary to observe that the vast majority of the oaks and beeches dealt with in this investigation were comparatively young trees, and it is,

TABLE I.

Numbers of the different trees encountered in each survey.

Survey	Sycamore	Oak	Beech	Elm	Birch	Spanish Chestnut	Fir	Lime	Horse Chestnut	Various	Unidentified	
1	24	7	32	5	2	7	2	9	16	31	2	137
2	63	3	123	38	4	7	1	22	16	25	1	303
3	88	2	72	114	4	9	51	3	12	54	1	410
4	32	3	56	28	1	2	17	4	...	7	...	150
5	293	378	159	67	44	39	11	61	15	100	2	1169
6	...	88	3	...	114	95	22	...	...	9	...	331
Total ...	500	481	445	252	169	159	104	99	59	226	6	2500

therefore, probable that surveys conducted in areas where old oaks and beeches are common would yield materially different results. Under the heading 'various' are included many species of trees, the most numerous of which were hawthorn (41) and holly (28).

In Table II are given the results of examining all places in the trees which, from ground level, appeared capable of lodging water. Twenty-seven per cent. of all such places tested contained water; they comprised eighty-three holes containing water in seventy-four trees, and fifty-one forks or clefts containing water in forty-six trees. It must be observed, however, that in the category 'holes containing water' we have included at least twenty in which the total amount of water obtained was not more than two ounces. Remarkable variation in the number of holes found in the trees is seen, for example in survey one, nine holes containing water were found in one hundred and thirty-seven trees, whereas in survey six, no hole containing water was found in three hundred and thirty-one trees. The explanation of this variation is, we believe, to be sought less in

FIG. 1

FIG. 2

SIPHON APPARATUS IN USE

Photographs by Miss M. Brown *C. Tinling & Co., Ltd., Imp.*

the character of the area—suburban or country—or in the tended and untended state of the trees, than in the species of tree present in the area under survey. Rot-holes in elms, horse-chestnuts, and sycamores were found to contain water more frequently than those in some other species; for example, in the limited number (about eighty) of old oaks examined rot-holes which did not contain water were numerous. Spanish chestnuts, firs, birches and young oaks presented few rot-holes.

TABLE II.

Analysis of examinations made during each survey.

Survey	Total trees examined	Trees in which places were tested	Places tested	Holes				Forks and Clefts			
				Total holes examined*	Trees involved	Total holes containing water	Trees involved	Total forks and clefts examined*	Trees involved	Total forks and clefts containing water	Trees involved
1	137	33	46	28	22	9	8	18	14	5	5
2	303	63	73	49	43	14	13	24	23	10	10
3	410	62	91	85	56	19	17	6	6	1	1
4	150	51	77	34	26	7	6	43	31	15	10
5	1169	143	191	134	103	34	30	57	53	20	20
6	331	18	21	15	14	...	...	6	4	...	...
Totals ...	2500	370	499	345	264	83	74	154	131	51	46

* The interpretation of 'holes, forks and clefts examined' as used here is given on p. 116.

The frequency with which breeding-places of tree-hole mosquitoes occurred in two thousand five hundred trees is shown in Table III. In the same table are seen the species of tree which most commonly harboured these insects. *Anopheles plumbeus* was found on sixteen occasions, always in true rot-holes, thrice alone, and thirteen times associated with *O. geniculatus*. The latter species was found on nineteen occasions, eighteen times in holes and once in a fork, five times alone and thirteen times associated with *A. plumbeus*. It will be seen, therefore, that *A. plumbeus* occurred in 0·64 per cent. of the trees examined and in 19·2 per cent. of the holes containing water. Excepting the Delamere survey, the breeding-places showed almost uniform distribution.

TABLE III.

Distribution of breeding places of *A. plumbeus* and *O. geniculatus* in holes or forks and clefts among the trees examined.

Kind of tree	Number examined	No. of holes containing water	No. of holes in which larvae of both mosquitoes were found	No. of holes in which larvae of *A. plumbeus* only were found	No. of holes in which larvae of *O. geniculatus* only were found	No. of forks and clefts containing water	No. of forks and clefts in which larvae of both mosquitoes were found	No. of forks and clefts in which larvae of *A. plumbeus* only were found	No. of forks and clefts in which larvae of *O. geniculatus* only were found
Sycamore ...	500	23	5	...	1	10	...	...	...
Oak	481	3	...	...	...	2	...	...	...
Beech ...	445	15	...	...	2	35	...	...	1
Elm ...	252	25	4	2	...	1	...	...	...
Birch ...	169	2	...	...	1	...	...	...	...
Spanish Chestnut	159	...	...	...	...	...	...	...	...
Fir	104	...	...	...	...	...	...	...	...
Lime ...	99	2	...	...	...	3	...	...	...
Horse Chestnut	59	9	3	1	...	...	...	...	...
Various ...	226	3	1*	...	1†	...	...	...	...
Unidentified	6	1	...	...	...	...	...	...	...
Totals ...	2500	83	13	3	5	51	...	...	1

* Ash.
† Norway Maple.

The number of places containing water, including the number of breeding-places easily visible and attainable and those which were less easily seen and approached, is shown in Table IV. In all cases the numbers are considerably greater above six feet from the ground, the number of breeding-places of *A. plumbeus* being three times as large at the higher level.

The frequency with which holes in sycamores occur at, or below, the six feet level as compared with greater heights is noteworthy. The apertures, also, are often large and conspicuous, and, in this district unless detailed examinations are made, the erroneous impression is obtained that the sycamore is the most favourable tree for harbouring these mosquitoes. Elms, on the other hand, appear

TABLE IV.

Distribution of places containing water and breeding places in trees at heights up to six feet from the ground, and from above six feet to twenty-five feet.

Kind of tree	Up to 6 feet				Above 6 feet to 25 feet*			
	Holes	Forks and clefts	Breeding places of *A. plumbeus*	Breeding places of *O. geniculatus*	Holes	Forks and clefts	Breeding places of *A. plumbeus*	Breeding places of *O. geniculatus*
Sycamore ...	12	4	3	4	11	6	2	2
Beech	6	4	...	...	9	31	...	3
Elm	4	...	1	1	21	1	5	3
Horse Chestnut ...	1	...	...	...	8	...	4	3
Others	4	4	...	1	7	1	1	2
Totals	27	12	4	6	56	39	12	13

* Of the holes in elms two were situated at 27 ft. and 28 ft. respectively (see p. 115).

at first sight much less favourable, whereas in reality they are more so; but in them, holes are often inconspicuous and usually occur at considerable heights, so that, in ordinary circumstances, they are difficult to observe.

NUMBERS OF LARVAE AND BREEDING-PLACES

Christophers and Khazan Chand (1916), who worked with the closely related *A. culiciformis*, Cog., of Southern India, write: 'At Pudupadi the larvae were found in about 10 per cent. of the tree-holes holding water. They were found both in large holes holding several gallons and in quite small holes. . . The largest number of larvae taken in one hole was about twenty, very frequently only one or two were found.'

During the present investigation we made counts of larvae from two holes, with the following results:—

Count 1.—92 larvae; all *A. plumbeus*.

Count 2.—346 larvae; 117 *A. plumbeus*, 229 *O. geniculatus*.

The above enumerations were made as exhaustive as possible by, first, the withdrawal of as much water as could be obtained by

siphonage, and, second, the removal of all sediment, and the rotten wood from the sides of the cavity, for examination. In the first case the cavity was small—4 in. by 5 in. by 4 in. deep—and the sediment was not in large amount, so that it was possible to place the whole contents in a large jar and to collect the larvae as they rose to the surface. In the second case the cavity was extensive (13 in. by 20 in. by 17 in. deep) and contained a large amount of sediment and much decayed wood. The water and large bulk of débris from this hole were taken to the laboratrory and by a process of dilution and decantation were systematically searched for larvae. In this case owing to the great mass of material and the pressure exerted in the course of transport, with resulting mortality among the larvae, it is certain that the numbers of larvae given are considerably below the numbers actually present in the cavity.

The smallest number of *A. plumbeus* larva obtained from a breeding-place by siphonage was one. But in this connection it must be stated that in the case of the first count mentioned above, in which ninety-two larvae were enumerated from the breeding-place, two only were obtained by the process of siphonage. It is evident, therefore, that our figures for breeding-places are too low, owing to the fact, stated previously, that only twenty-five feet of the trees were examined, and also because even in that twenty-five-foot height not all breeding-places are detected, since the evacuation of larvae from small breeding-places with little surface water and much sediment cannot be assured.

Size of the Larvae

There was considerable variation in the size of the larvae present in the breeding-places, large and small forms of both species being found. On one occasion, 30th March, numerous newly-hatched *O. geniculatus* larvae were obtained from a hole in a sycamore tree.

General Discussion of Results obtained

In a previous paper (1920) we ventured to express the opinion that before an area can be considered free from *A. plumbeus* a careful examination of each tree in that area must be made. We are much strengthened in our belief that this opinion is correct by our experience in the surveys just completed. The examination of

two thousand five hundred trees does not sound a formidable task, but if carried out systematically, even to the height of twenty-five feet—which may be quite insufficient—it will be found to be a distinctly arduous and exhausting procedure. The winter months appear to be the best for such investigations, because there is little foliage to obstruct the view. Towards the end of April we experienced some difficulty owing to the early leaves rendering it necessary to scrutinize extremely carefully each bough. Two excellent breeding-places of *A. plumbeus* in a horse-chestnut were nearly overlooked owing to this factor.

The apparatus which we used could with advantage be improved upon, especially in regard to the screw-on joints of the extensions. The repeated screwing and unscrewing of narrow bore tubing with the hands or with pliers is irksome. Some more rapid method of fixing the extensions would reduce the labour greatly. It should be borne in mind that the joint between the extensions must stand a pull as well as a push, because frequently the curve on the head-piece catches on twigs on being drawn down.

SUMMARY

1. In a series of six surveys, five in the Liverpool district and one in Delamere Forest, Cheshire, two thousand five hundred trees were examined up to a height of twenty-five feet for breeding-places of *Anopheles plumbeus* and *Ochlerotatus geniculatus*.

2. A total of eighty-three holes and fifty-one forks and clefts containing water were found.

3. Sixteen breeding-places of *A. plumbeus* and nineteen breeding places of *O. geniculatus* were discovered; larvae of *A. plumbeus* and *O. geniculatus* were associated on thirteen occasions. Breeding-places of *A. plumbeus* occurred in 0·64 per cent. of the trees examined, and in 19·2 per cent. of holes containing water.

4. Up to a height of six feet from the ground, thirty-nine places containing water, four breeding-places of *A. plumbeus* and six of *O. geniculatus* were found; above six feet, ninety-five places containing water, twelve breeding-places of *A. plumbeus* and thirteen of *O. geniculatus* were found.

5. Elms, horse-chestnuts and sycamores provided the great majority of the breeding-places; oaks, Spanish chestnuts and firs provided no breeding-places and very few holes containing water.

ACKNOWLEDGMENTS

Our thanks are due to The Right Honourable The Earl of Derby, K.G., G.C.V.O., for permission to examine trees at Knowsley Park; to D. Hamilton, Esq., for affording us every facility in our work there; and to Dr. Rundle, for permission to examine the trees at Fazakerley Hospital.

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Blacklock, B., and Carter, H. F. (1920) Observations on *Anopheles* (*Coelodiazesis*) *plumbeus*, Stephens, with special reference to its breeding places, occurrence in the Liverpool district, and possible connection with the spread of malaria. *Ann. Trop. Med. and Parasit.* Vol. XIII, pp. 421-452.

Christophers, S. R., and Khazan Chand (1916). A tree-hole breeding *Anopheles* from Southern India: *A.* (*Coelodiazesis*) *culiciformis*, Cogill, *Ind. Journ. Med. Res.* Vol. III, pp. 638-645.

Note.—Larvae of *A. plumbeus* have been observed from the following additional localities:—

ENGLAND

Liverpool District—

Calderstones Park. Breeding place in an elm. 8.4.1920.

IRELAND

County Armagh—

Newry, The Glen (border of Co. Armagh and Co. Down). Breeding place in a beech. By kind permission of Mrs. Barcroft. 23.3.1920.

County Derry—

Moyola Park, Castledawson. Breeding place in a beech (observer, Miss M. G. Thompson, M.B.). 20.4.1920.

Between Magherafelt and Moneymore. Breeding place in a horse chestnut (observer, Miss M. G. Thompson, M.B.). 20.4.1920.

Glenburn (near Portglenone, border of Co. Derry and Co. Antrim). Breeding place in a beech (observer, Miss M. G. Thompson, M.B.). 27.4.1920.

County Louth—

Ravensdale Park, Ravensdale. Breeding place in a beech. 20.3.1920.

Anaverna, Ravensdale. Breeding places in a beech and a fallen elm. 20.3.1920.

CROSSOCEPHALUS ZEBRAE, N.SP.

BY

WARRINGTON YORKE

AND

T. SOUTHWELL

(*Received for publication* 20 *May*, 1920)

This nematode was present in considerable numbers in the collections made from the intestine of six zebrae (*Equus burchelli*) shot by one of us in Northern Rhodesia, 1912.

SIZE AND SHAPE. It is a moderately small species, the female being slightly larger than the male. Four sexually mature males and ten females were measured. The males were from 7·6 mm. to 8·3 mm. in length, average 8·0 mm.; the females from 7·4 mm. to 9·4 mm., average 8·6 mm.; the greatest breadth averaged, males 440μ, females 498μ. The anterior extremity is truncated; the posterior extremity of the male is inrolled ventrally and that of the female straight and tapering.

THE HEAD. The anterior end of the body tapers very slightly to the head, which is sharply truncated; there is no definite neck (figs. 1 and 2).

Lips. The mouth is surrounded by three lips (one dorsal and two sub-ventral), each lip, on its oral aspect, being sub-divided into three portions, and having a finely serrated edge (fig. 5).

Head papillae. There are numerous (fifteen) head papillae having a complicated arrangement as shown in figs. 1-5. The lateral papillae (*a*) are very prominent; there are four sub-median papillae (*b*) just projecting beyond the surface of the lips; there is also an additional papilla (*c*) situated at the middle of each lip; and finally there are three pairs of small papillae (*d*) arranged so that one papilla lies on each side of the junctions of the three lips.

There is no chitinised mouth capsule, but there are three pairs of pectinated laminae situated in the anterior end of the oesophagus (figs. 1 and 2). Each of these laminae bears from eight to eleven pointed teeth, the points being directed backwards when the mouth

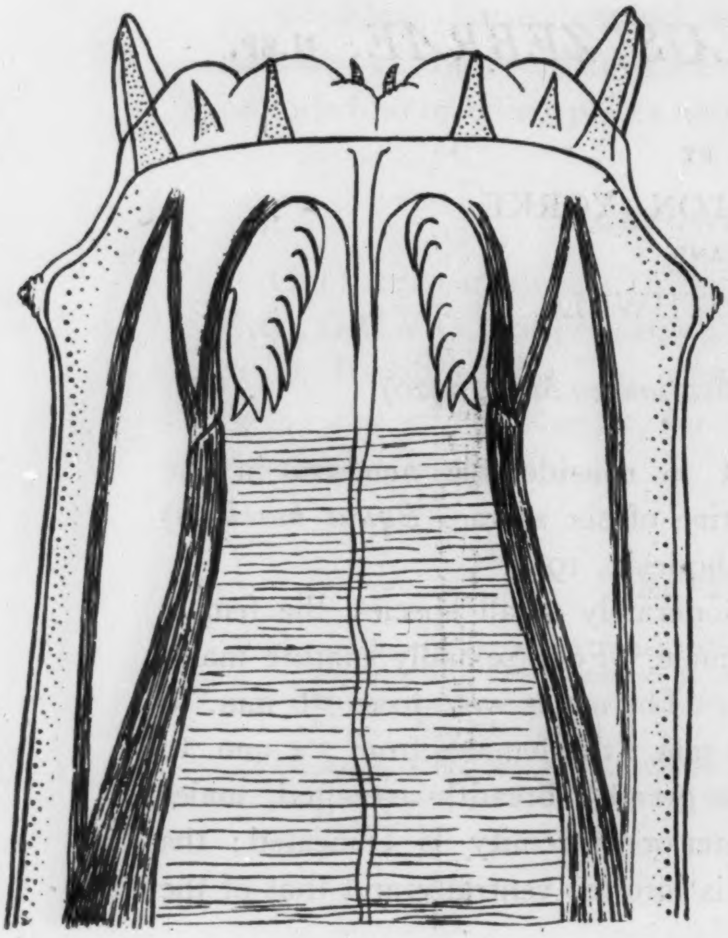

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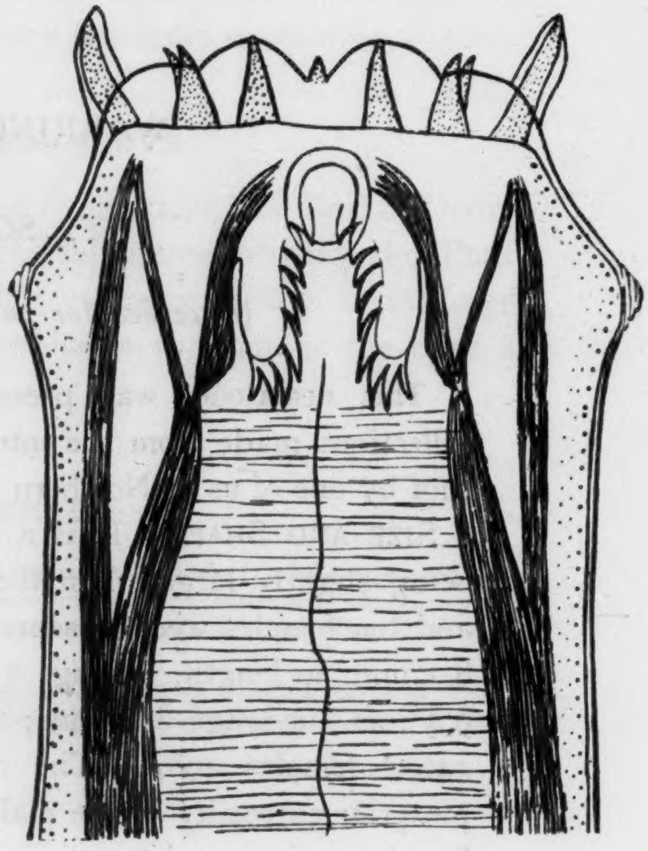
FIG. 1. *Crossocephalus zebrae.*
Anterior extremity, ventral view, mouth closed. × 360.



A. M. B. del.

FIG. 2. *Crossocephalus zebrae.*
Anterior extremity, dorsal view, mouth closed. × 360.

is closed. The mouth is, however, capable of being everted, in which condition the lips are folded back over the anterior end of the worm, the papillae being directed backwards; the anterior portion of the oesophagus then forms the anterior end of the worm, the six pectinated laminae being erected and their teeth directed forwards (figs. 3 and 4). Eversion is probably to a considerable extent brought about by the action of certain prominent longitudinal muscles which are shown in figs. 1 and 2.

The duct of the *dorsal oesophageal* gland opens into the mouth (fig. 5. *g*).

OESOPHAGUS. The length of the oesophagus in seven female worms, in which the mouth was closed, varied from 1,016μ to 1,085μ, the average being 1,045μ. When the mouth is open there is an apparent shortening of the oesophagus to the extent of about

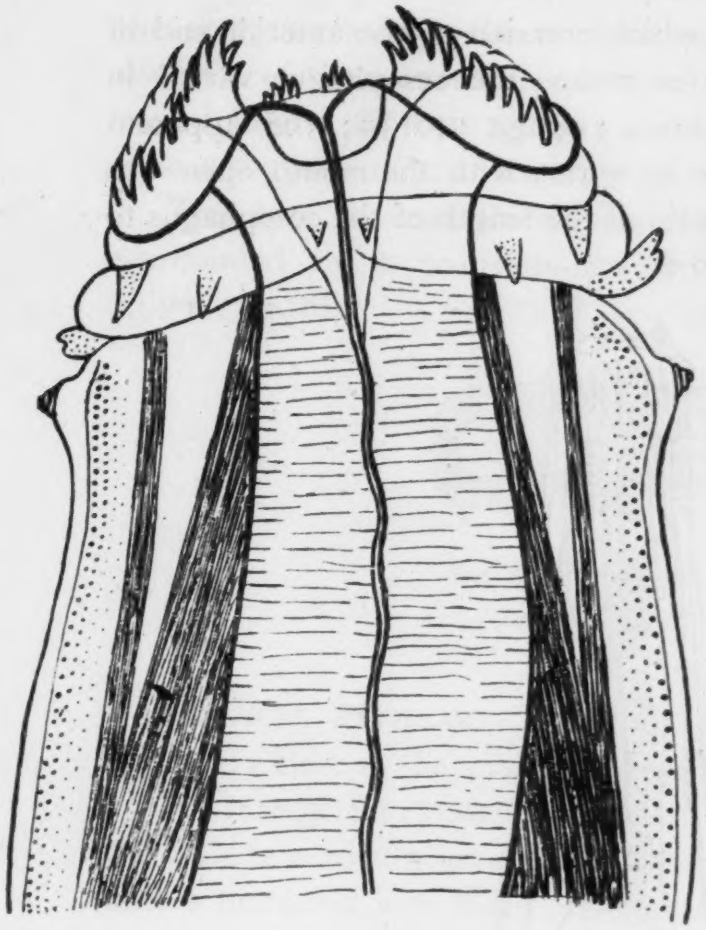


FIG. 3. *Crossocephalus zebrae.*
Anterior extremity, ventral view, mouth everted. × 360.

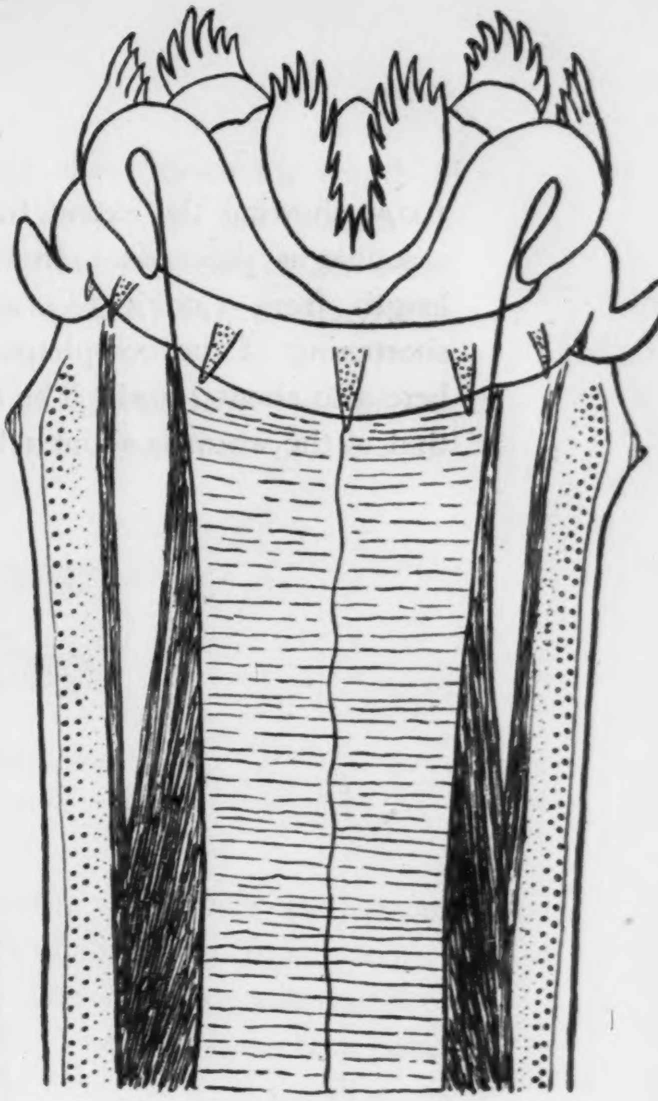


FIG. 4. *Crossocephalus zebrae.*
Anterior extremity, dorsal view, mouth everted. × 360.

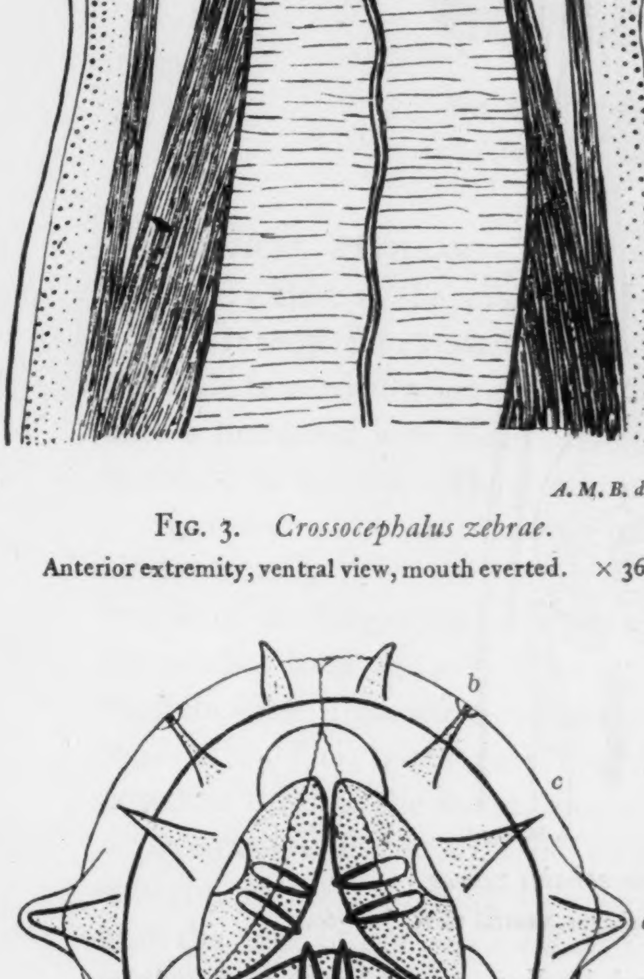


FIG. 5. *Crossocephalus zebrae.*
End-on view of head, mouth slightly everted, shewing position of the various papillae; a = lateral papillae, b = sub-median papillae, c = papillae on middle of each lip, d = paired papillae, g = duct of dorsal oesophageal gland. × 360.

FIG. 6. *Crossocephalus zebrae.*
Transverse section through oesophagus at level of cervical papillae. × 360.

100μ, showing the extent to which eversion of the anterior end of oesophagus proceeds. In three males, the oesophagus varied in length from $1{,}002\mu$ to $1{,}020\mu$; average $1{,}013\mu$; the apparent shortening of the oesophagus in worms with the mouth open was here also about 100μ. The ratio of the length of the oesophagus to that of the worm is about 1 to 8.

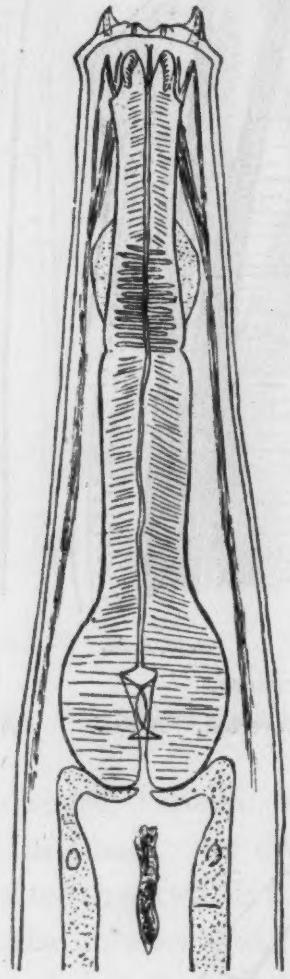


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FIG. 7. *Crossocephalus zebrae.*
Anterior end showing oesophagus, ventral view. × 360.

A series of yellow club-shaped bodies, possibly of a glandular nature, occur in the wall of the oesophagus; these commence about 220μ from the anterior extremity of the worm, and they extend backwards for a distance of about 70μ. The bulb of the oesophagus contains a valvular arrangement consisting of three ridges projecting into the lumen. The appearance of the above structures is shown in fig. 7.

EXCRETORY PORE. This is situated about twice the length of the oesophagus from the anterior extremity. In ten females the distance of the excretory pore from the anterior end of the worm varied from 1,866μ to 2,110μ; average 2,041μ; and in four males from 2,027μ to 2,172μ; average 2,110μ.

The pore presents the appearance of a transverse slit, and is surrounded by a pallisade-like structure consisting of cuticular ridges (fig. 8).

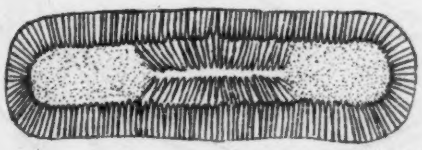
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FIG. 8. *Crossocephalus zebrae.*
Excretory pore. × 240.

CERVICAL PAPILLAE. These are small, nipple-like projections lying very close to the anterior extremity of the worm (figs. 1 to 4).

POSTERIOR EXTREMITY OF MALE. The posterior extremity of the male is markedly inrolled, ventrally. The tail tapers to a point and is furnished with three pre-anal and five post-anal papillae, as is shown in fig. 10. There are no membranous expansions.

Spicules. The spicules are unequal in size, the larger being almost exactly twice the length of the smaller. In eight worms the length of the larger varied from 295μ to 353μ; average 330μ, and the smaller from 145μ to 176μ; average 165μ. The larger spicule exhibits fine transverse striations; the smaller is not striated (fig. 11). The testes and ejaculatory duct are limited to the posterior third of the worm, and are shown in fig. 9.

POSTERIOR EXTREMITY OF FEMALE. The end of the female is straight, the tail tapering to a point. In nine worms the distance from the anus to the vulva varied from 170μ to 255μ, average 195μ; and the distance of the anus from the tip of the tail from 488μ to 617μ, average 551μ (fig. 12).

There is a single tubular ovary the anterior extremity of which lies about 300μ behind the excretory pore. The oviduct runs forward for a short distance and then dilates into a receptaculum seminis. The uterus is a thin-walled sac and reaches nearly as far

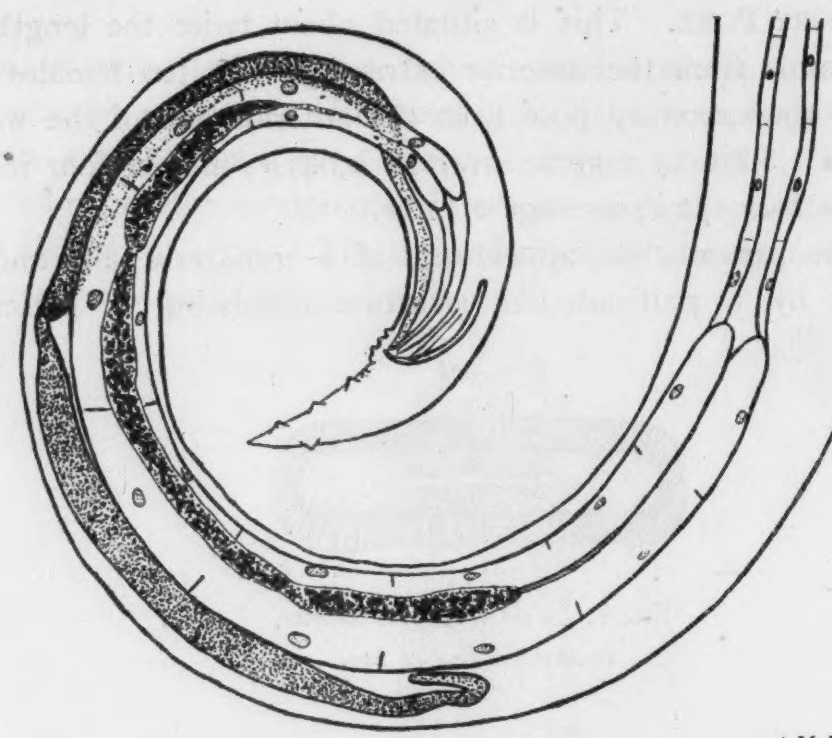

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FIG. 9. *Crossocephalus zebrae.*
Posterior extremity of male. × 45.

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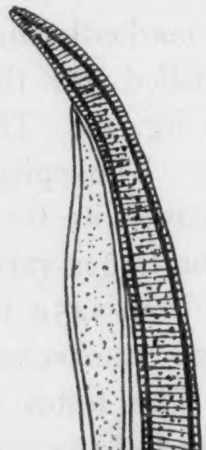

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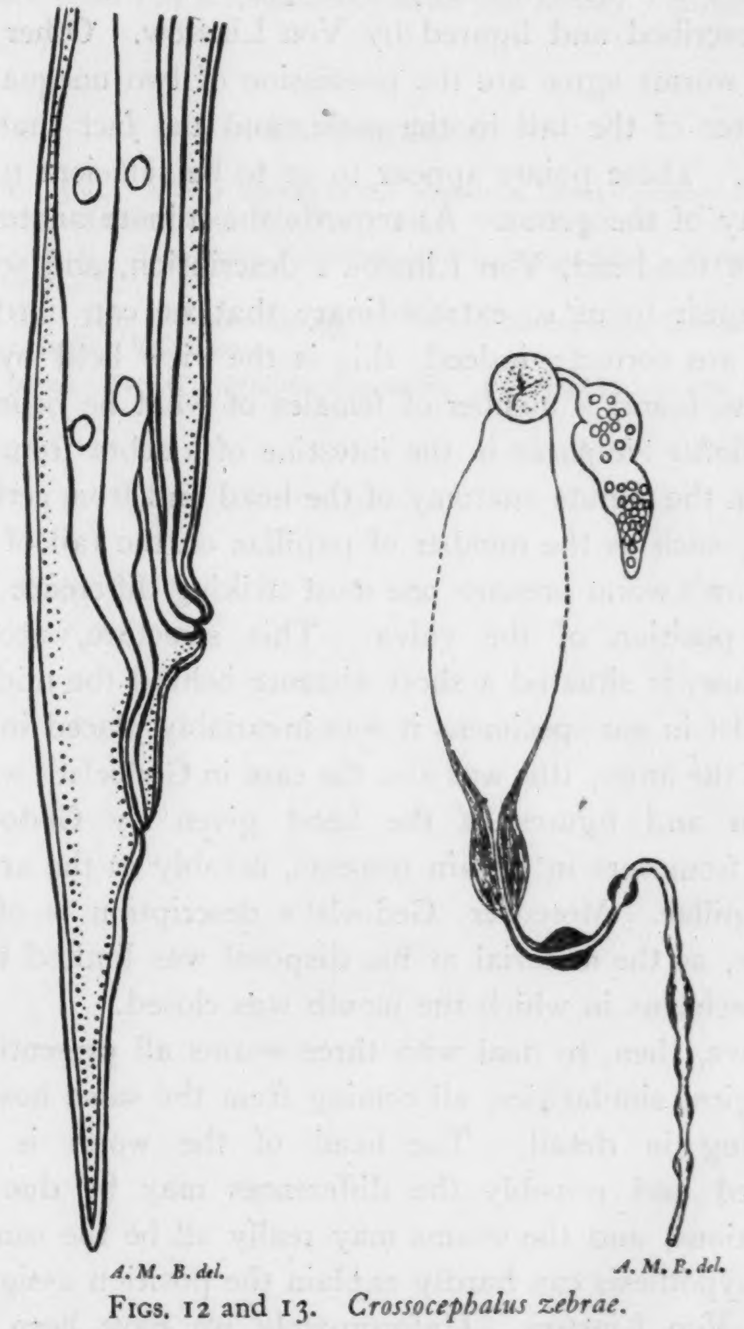
FIGS. 10 and 11. *Crossocephalus zebrae.*
Fig. 10. Posterior end of male. × 120. Fig. 11. Spicules. × 360.

posteriorly as the vulva; in gravid worms it contains one or more fully formed larvae which attain to a length equal to about half that of the parent worm; the larvae exhibit clearly the six pectinated laminae. In the posterior part of the uterus developing larvae can be seen. The vagina commences as a thick muscular tube and exhibits a beaded appearance due to numerous dilatations, it runs first posteriorly, and then anteriorly for a short course, and then directly posterior to the vulva (fig. 13).



FIGS. 12 and 13. *Crossocephalus zebrae.*

Fig. 12. Posterior extremity of female. × 120. Fig. 13. Diagram of female genitalia.

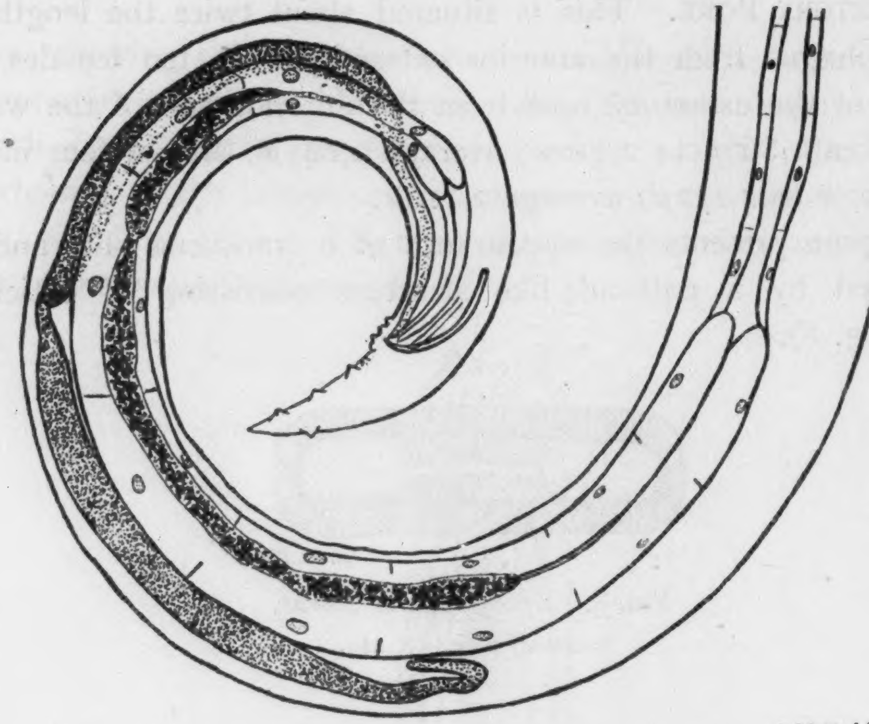
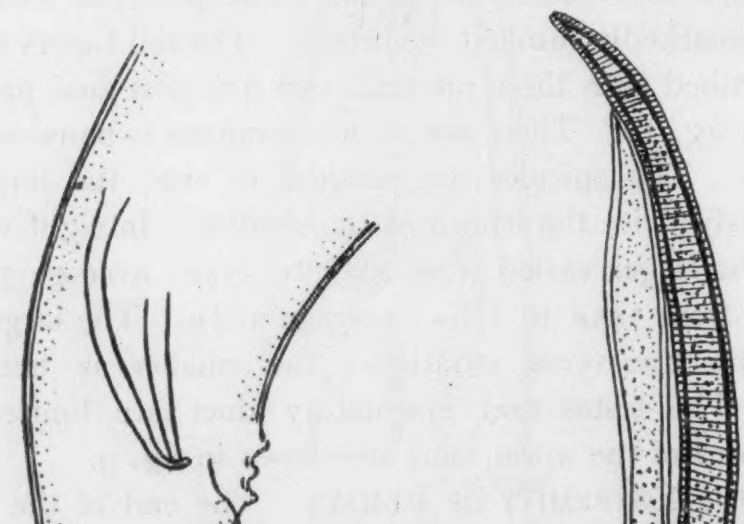


FIG. 9. *Crossocephalus zebrae.*
Posterior extremity of male. × 45.



FIGS. 10 and 11. *Crossocephalus zebrae.*
Fig. 10. Posterior end of male. × 120. Fig. 11. Spicules. × 360.

posteriorly as the vulva; in gravid worms it contains one or more fully formed larvae which attain to a length equal to about half that of the parent worm; the larvae exhibit clearly the six pectinated laminae. In the posterior part of the uterus developing larvae can be seen. The vagina commences as a thick muscular tube and exhibits a beaded appearance due to numerous dilatations, it runs first posteriorly, and then anteriorly for a short course, and then directly posterior to the vulva (fig. 13).

A. M. B. del.

A. M. B. del.

FIGS. 12 and 13. *Crossocephalus zebrae.*

Fig. 12. Posterior extremity of female. × 120. Fig. 13. Diagram of female genitalia.

DIAGNOSIS

This worm is probably closely related to the worm described by Von Linstow (1899) under the name *Pterocephalus viviparus*, and which was subsequently re-named *Crossocephalus* by Railliet in 1909, as the genus *Pterocephalus* was already occupied. We infer this from an examination of Von Linstow's figures rather than from a study of his written description of the worm. The six pectinated laminae of our worm obviously correspond to the '6 aufrichtbare Flügel' described and figured by Von Linstow. Other points in which the worms agree are the possession of two unequal spicules, the character of the tail in the male, and the fact that both are viviparous. These points appear to us to be sufficient to establish the identity of the genus. As regards the minute anatomy of the structure of the head, Von Linstow's description, and some of his figures, appear to us so extraordinary that we can hardly believe that they are correct; indeed, this is the view held by Gedoelst (1906), who found a number of females of what he believed to be *Crossocephalus viviparus* in the intestine of a zebra from Katanga. Apart from the minute anatomy of the head and from certain minor characters, such as the number of papillae on the tail of the male, Von Linstow's worm presents one most striking difference from ours, viz., the position of the vulva. This structure, according to Von Linstow, is situated a short distance behind the middle of the body, whilst in our specimens it was invariably placed immediately in front of the anus; this was also the case in Gedoelst's worm. The description and figures of the head given by Gedoelst differ markedly from ours in certain respects, notably in the arrangement of the papillae. Moreover, Gedoelst's description is of necessity incomplete, as the material at his disposal was limited to females, and to specimens in which the mouth was closed.

We have, then, to deal with three worms all presenting certain morphological similarities, all coming from the same host, and yet all differing in detail. The head of the worm is extremely complicated and possibly the differences may be due to faulty interpretations, and the worms may really all be the same species. But this hypothesis can hardly explain the position assigned to the vulva by Von Linstow. Unfortunately we have been unable to

examine Von Linstow's co-types, and so cannot offer a definite opinion on the matter. It appears to us, therefore, that the proper procedure is to act on the assumption that the description given by Von Linstow is correct, and to regard our worm as a new species, *Crossocephalus zebrae*.

Attention might be drawn to the fact that Baylis (1919) has recently given the name *Crossocephalus longicaudatus* to a closely allied species found in a rhinoceros from the Malay Peninsula.

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examine Von Linstow's co-types, and so cannot offer a definite opinion on the matter. It appears to us, therefore, that the proper procedure is to act on the assumption that the description given by Von Linstow is correct, and to regard our worm as a new species, [illegible].

Attention might be drawn to the fact that Baylis (1919) has recently given the name [illegible] to a closely allied species found in a rhinoceros from the Malay Peninsula.

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Baylis, H. A. (1919). A New Species of the Nematode Genus [illegible] from the [illegible]. Ann. Mag. Nat. Hist., ser. 9, Vol. [illegible], p. [illegible].

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TARTAR EMETIC IN GUINEA-WORM INFECTIONS

BY

J. W. S. MACFIE

(*Received for publication 22 June, 1920*)

PLATE II

On a previous occasion (1920) an account was published of the effects of intravenous injections of tartar emetic in ten cases of guinea-worm infection. Since this preliminary note was written a few additional observations have been made on the same cases, and a few new cases have been treated, so that details are now available of the effects observed in twenty-three patients and on thirty-nine worms. In the present paper the results of the treatments are briefly summarised. The data regarding the cases are given in the Table. All the patients were treated at Accra. I have again to thank Dr. A. J. R. O'Brien for very kindly permitting me to make use of notes made on cases in his charge.

TECHNIQUE OF TREATMENT

Excepting on rare occasions, the tartar emetic was administered in doses of one grain each, and was given every other day. The injections were made into a vein at the bend of the elbow with a 'Record' syringe and a fine needle. The strength of the solution employed, which was made up with normal saline solution and contained 0·5 per cent. phenol, was 0·5 of a grain of tartar emetic in each cubic centimetre; this solution was found to be the most convenient and suitable for general use. The solution should always be freshly prepared before use. On one or two occasions (Cases Nos. 21, 22, 23) a stock solution which had been prepared two or three months previously was used, and was found to give disappointing results. Better results followed immediately in these cases when a freshly prepared solution was substituted. It is

possible that some of the other less successful results in earlier cases may be accounted for in the same manner.

Many of the cases were treated as out-patients. Cases treated in hospital, where they were able to rest completely, appeared to do better, however, and were sooner fit to return to their employments. This was most noticeable in patients in whom the worm had already set up a considerable degree of inflammation.

No serious ill-results were observed to follow the injections. In two cases, after four and three grains respectively, a slight general papular rash developed, which, however, disappeared when the treatment was discontinued; and Dr. O'Brien reported that one of his patients showed symptoms of collapse after injection on one occasion.

EFFECTS ON THE GUINEA WORMS

Intravenous injections of tartar emetic will kill guinea-worms and the embryos in them. In one or two cases the effect has been observed on worms situated superficially and visible beneath the skin (*e.g.*, Case No. 15; Plate II, figs. 1 and 2). In such cases the worm soon became stationary, and was slowly absorbed. The worms have also been examined microscopically at various stages of treatment by extracting small portions of them and searching them for embryos. Pieces of sixteen worms were removed and examined during the courses of antimony treatment, fourteen once only and two on two occasions. Living embryos were found in worms after two and a half, three, three, four, five, and six grains, after a previous course of six grains and one recent dose of one grain, and after ten, ten, and fourteen grains of an old preparation which was probably not of full strength. Dead or disintegrated embryos only were found in worms after four, four, four, four, four and a half, five, seven, and seven grains. The two worms which were examined in this manner twice showed living embryos on the first occasion, after two and a half and four grains, and only dead embryos on the second occasion, after four and a half and seven grains respectively. It is clear, therefore, that the same dose of tartar emetic does not always have the same lethal effect,

some worms being killed, and their embryos with them, by four grains, others successfully withstanding larger doses.

From these results there can, I think, be no doubt that injections of tartar emetic will kill guinea-worms and their embryos: the results are, however, not always similar. Most frequently the worms remain in the body, and are gradually absorbed. In some cases the greater part of the worm remains in the body and is absorbed, but one or more pieces of dead worm slough before the wound becomes soundly healed. In other cases the worm appears in the wound, and can be extracted without difficulty or danger. So complete was my confidence in the efficacy of tartar emetic that during treatment I frequently pulled out and broke off protruding portions of the worms in order that the remainders might retract and permit of the healing of the external wounds. No ill-effects followed this practice, which under other circumstances would inevitably have resulted in acute inflammation and abscess formation.

In several cases the treatment appeared to have the effect of bringing to the surface other guinea-worms that happened to be in the body. The worms sometimes reached the skin surface alive (Cases Nos. 15, 27), sometimes dead (Case No. 14), and sometimes they failed to make their way through to the surface, and only succeeded in getting so far that they became palpable or produced local swellings.

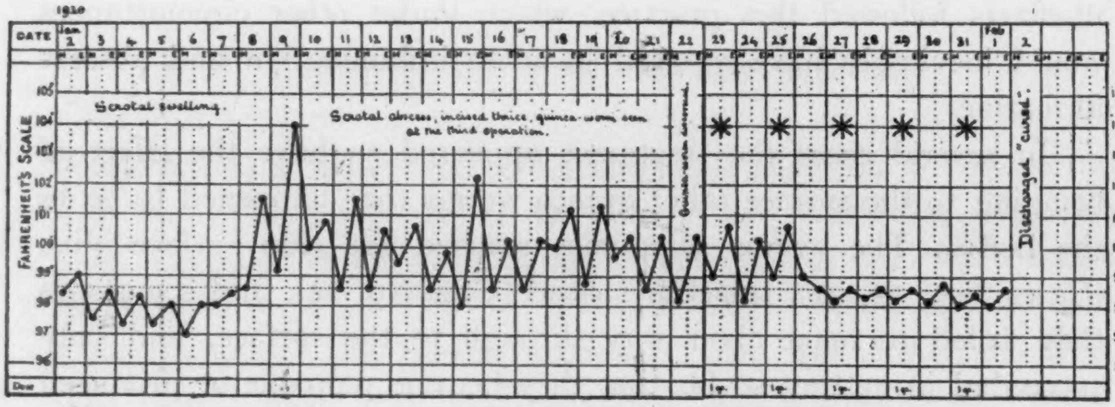
EFFECTS IN REDUCING INFLAMMATION

The injections of tartar emetic appeared to relieve inflammation as well as to kill the guinea-worms. So notable was this effect that it was thought that the treatment might prove of value in dealing with inflammation and suppuration due to other causes. No opportunity having yet occurred of putting this to the test, it may be of interest to recount here briefly two of the cases in which this action appeared to be well marked.

Case No. 13 (see Chart). This patient was admitted to hospital suffering from orchitis, and developed an abscess on the left side of his scrotum. The abscess was opened three times, nevertheless the inflammation and the fever persisted. At the third

operation a guinea-worm was seen in the scrotum, and in consequence intravenous injections of tartar emetic were started next day. The fever subsided, the inflammation was arrested, and the wounds healed after the second injection.

Case No. 14. This patient had a guinea-worm in his right foot, which was cured after the injection of four grains of tartar emetic. A fortnight later a swelling appeared in the left groin and came to a head. It was punctured, about a drachm of pus was let out, and a guinea-worm was seen. The guinea-worm was dead; no embryos were found in the discharge from the wound, and only disentegrated ones in a small piece of the worm removed for microscopical examination. As the worm and its embryos were dead, it was anticipated that the swelling would subside and that the



Temperature Chart of Case No. 13. * = intravenous injection of one grain of tartar emetic.

wound would heal without special treament other than that usually applicable to such an abscess. This did not occur immediately, however, and four days later intravenous injections of tartar emetic were restarted. The inflammation began to subside at once, and the wound healed rapidly.

Many other cases might be instanced in which the inflammation of the affected limb and the discharge from the guinea-worm sore appeared to respond immediately to intravenous injections of tartar emetic, but in some of them there was the possibility, not present in the two cases mentioned above, that the relief of the inflammation might have been due to the killing of living embryos which had invaded the tissues.

EFFECT ON THE DURATION OF THE INFECTION

It is not possible to estimate accurately the reduction in the duration of the illness due to guinea-worm infections effected by the use of intravenous injections of tartar emetic because there are not available data showing the usual duration, and because, naturally enough, the length of the illness depends very largely on the condition of the patient on admission, the nature of the treatment previously adopted, the site of the worm, and on many other circumstances. Cases similar to those dealt with in this paper when treated by the older methods are generally reckoned, however, to be unfit for work for about six weeks, very much longer if a succession of worms develops.

In those of our cases in which the infection was single and was not complicated by some other affection, the average length of time from admission to discharge was about twelve days. In some cases it was less, in some considerably more.

It may be affirmed, therefore, that the treatment effects a real reduction in the duration of the illness, besides reducing the liability to the more serious consequences attending other forms of treatment.

THE DOSB OF TARTAR EMETIC REQUIRED

Definite proof has, I believe, been obtained that the intravenous injection of four grains of tartar emetic is sufficient in many cases to kill a guinea-worm and the embryos in it. This dose, however, is not invariably sufficient. It has been noted also that in the same patient, after one guinea-worm has been cured by this treatment, other guinea-worms may make their appearance at the surface of the body. These rather conflicting results suggest that all guinea-worms are not equally susceptible to the drug, and that either in certain stages of their development, or in certain situations in the body, they are less easily killed than when they have come naturally to the surface for the purpose of discharging their embryos.

It may be suggested that to give every other day an injection of one grain of tartar emetic until a total dose of six grains has been administered would be found to be satisfactory treatment in most cases. In the event of relapse or recurrence, a second course should

be given. Further experience may show that, in some cases at any rate, longer courses are necessary, and that it is preferable to augment both the individual and the total dose, but the cases collected in the Table show that very satisfactory results may follow courses of as few as four or five injections of one grain each.

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TABLE

R = right; L = left; C = cured (in the clinical sense).

An injection, unless otherwise stated, is 1 grain of tartar emetic.

Case No.	Approximate age in years	Total dose of tartar emetic given; in grains	Patient last seen ...... days after cessation of treatment	Site of the guinea-worm	Condition when treatment started	Result	Remarks
1	20	9	48	L. leg	Worm broken; leg swollen and painful; fever	C.	No bits of worm came away.
2	23	5	30	L. leg	Whole worm in the body	C.	Worm did not come away.
3	30	6	35	L. foot	Whole worm in the body	Worm extracted	Sore closed, but re-opened a week after cessation of treatment, worm protruded and was wound out.
4	24	4	44	R. leg	Whole worm in the body; leg much swollen	C.	Worm did not come away
5	15	5½	21	R. leg	Whole worm in the body	C.	A bit of the worm was pulled out and broken off, the remainder did not come away
6	47	6	68	L. leg	Worm broken; sore granulating and discharging	C.	No bits of worm came away
7	30	6	70	L. foot	Worm broken, foot swollen	C.	A bit of worm sloughed out three days after last dose; sore then healed. No relapse
				L. foot	Whole worm in the body	Worm extracted	Worm appeared after the third injection; extracted
8	18	4 + 7	...	L. foot	Whole worm in the body	C.	After four injections patient went away for a month; returned with sore open and septic, and leg swollen. Rapidly healed after treatment resumed. Returned with a guinea-worm in the right foot also.
				R. foot	Whole worm in the body	Worm extracted	After 4 grains, piece of worm pulled off: embryos in it were dead. After 7 grains the rest of the worm was easily extracted
9	30	3½	69	R. foot	Worm broken; foot swollen and tender	C.	No bits of worm came away.
10	22	4	...	R. foot	Worm broken; foot swollen and tender	Improved	Patient went away and was not seen again.
11	20	6	52	R. foot	Worm broken	Worm extracted	
12	26	5	26	R. foot	Worm broken; foot swollen and inflamed	C.	No bits of worm came away
13	18	5	10	Scrotum	Worm broken; scrotal abscess. Fever	C.	Temperature fell to normal and abscess wound healed after the second injection

TABLE—*continued*

Case No.	Approximate age in years	Total dose of tartar emetic given; in grains	Patient last seen ...... days after cessation of treatment	Site of the guinea-worm	Condition when treatment started	Result	Remarks
14	15	4 + 4	42	R. foot	Worm broken; foot and leg swollen	C.	No bits of worm came away. A fortnight after discharge from hospital a swelling appeared in the left groin forming an abscess.
				L. groin	Whole worm in the body	C.	Groin swelling opened and a piece of guinea-worm removed before resuming treatment; it contained only dead embryos. Abscess healed rapidly, and swelling subsided.
15	18	6 + 5½	44	R. side of body	Whole worm in the body	C.	Worm subcutaneous: slowly absorbed, neither visible nor palpable when last examined. Ten days after the first course of treatment the second worm appeared.
				R. groin	Whole worm in the body	C.	Piece of worm removed after the first injection: embryos in it living. Healed after the second injection. A week later two inches of dead worm sloughed, then sore healed again and has not given further trouble
16	48	5	6	L. foot	Whole worm in the body	C.	Six inches of disintegrated worm extracted after 4 grains had been given; the remainder did not come away. A second worm appeared a week after discharge.
17	22	3 + 3	...	R. foot	Whole worm in the body; abscess	Improved	A week intervened between the third and the fourth injections; living embryos were still present when treatment resumed. Practically healed when last dose given, after which patient ceased to attend for treatment.
18	20	3	...	R. foot	Whole worm in the body; foot swollen	C.	Cleared up after two injections
19	20	3	27	L. leg	Whole worm in the body; leg swollen, abscess	Worm extracted	Six inches of worm pulled off after first injection. Four days after last injection abscess burst and rest of worm was easily extracted. No further trouble.
20	34	6	10	L. leg	Whole worm in the body; leg greatly swollen	C.	Inflammation and swelling subsided rapidly. Worm did not come away.
21	20	4 + 5 (old solution used for first six injections)	...	R. leg	Whole worm in the body	C.	Healed rather slowly after four injections
				R. ankle	Whole worm in the body	C.	Healed partially after the first course. A month later relapsed; living embryos present. Healed rapidly after treatment resumed
				R. foot	Whole worm in the body	Improved	Healed partially after the first course. Relapsed a month later. A piece of worm examined after thr e grains of second course contained only disintegrated embryos. Still under observation; doing well

TABLE—*continued*

Case No.	Approximate age in years	Total dose of tartar emetic given; in grains	Patient last seen ...... days after cessation of treatment	Site of the guinea-worm	Condition when treatment started	Result	Remarks
22	23	9 (old solution used for first six injections)	5	R. foot	Whole worm in the body	C.	Healed after the eighth injection
				R. leg	Whole worm in the body; abscess	Improved	Four inches of dead worm sloughed two days after the cessation of treatment. Still under observation: doing well, almost healed
				Perineum	Whole worm in the body; abscess	Worm extracted	Abscess burst two days after cessation of treatment and complete dead worm came away. Still under observation: doing well, almost healed
				L. foot	Whole worm in the body; abscess	Improved	Worm did not come away. Almost healed
23	24	6 + 4 + 6 (old solution used for first fourteen injections)	5	R. leg	Whole worm in the body; leg greatly swollen; fever	C.	Treated as out-patient during first course, then admitted to hospital and given four more injections which resulted in rapid healing. Worm did not come away. A week later patient returned with seven guinea-worms, and third course was started
				Abdomen	Whole worm in the body	Improved	Worm subcutaneous, small opening at head. Sore nearly healed; still under observation
				Abdomen	Whole worm in the body	Improved	Worm subcutaneous. Still under observation: worm palpable and still visible at one spot
				Back	Whole worm in the body	C.	Worm subcutaneous. Apparently cured; only just palpable, and apparently being absorbed
				L. thigh	Whole worm in the body	Improved	Worm subcutaneous. Still under observation; worm palpable but apparently being absorbed
				L. leg	Whole worm in the body	C.	Healed rapidly
				L. foot	Whole worm in the body	Improved	Still under observation: nearly healed
				R. foot	Whole worm in the body	Improved	Still under observation: nearly healed

TABLE—*continued*

Case No.	Approximate age in years	Total dose of tartar emetic given; in grains	Patient last seen ...... days after cessation of treatment	Site of the guinea-worm	Condition when treatment started	Result	Remarks
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TABLE—*continued*

Case No.	Approximate age in years	Total dose of tartar emetic given; in grains	Patient last seen ...... days after cessation of treatment	Site of the guinea-worm	Condition when treatment started	Result	Remarks
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				R. leg	Whole worm in the body; abscess	Improved	Four inches of dead worm sloughed two days after the cessation of treatment. Still under observation: doing well, almost healed
				Perineum	Whole worm in the body; abscess	Worm extracted	Abscess burst two days after cessation of treatment and complete dead worm came away. Still under observation: doing well, almost healed
				L. foot	Whole worm in the body; abscess	Improved	Worm did not come away. Almost healed
23	24	6 + 4 + 6 (old solution used for first fourteen injections)	5	R. leg	Whole worm in the body; leg greatly swollen; fever	C.	Treated as out-patient during first course, then admitted to hospital and given four more injections which resulted in rapid healing. Worm did not come away. A week later patient returned with seven guinea-worms, and third course was started
				Abdomen	Whole worm in the body	Improved	Worm subcutaneous, small opening at head. Sore nearly healed; still under observation
				Abdomen	Whole worm in the body	Improved	Worm subcutaneous. Still under observation: worm palpable and still visible at one spot
				Back	Whole worm in the body	C.	Worm subcutaneous. Apparently cured; only just palpable, and apparently being absorbed
				L. thigh	Whole worm in the body	Improved	Worm subcutaneous. Still under observation; worm palpable but apparently being absorbed
				L. leg	Whole worm in the body	C.	Healed rapidly
				L. foot	Whole worm in the body	Improved	Still under observation: nearly healed
				R. foot	Whole worm in the body	Improved	Still under observation: nearly healed

EXPLANATION OF PLATE II

Fig. 1. Case No. 15, showing the guinea-worm, situated under the skin of the chest and abdomen, as it appeared at the time treatment was started.

Fig. 2. The same case after administration of four grains of tartar emetic. The upper (tail) portion of the guinea-worm was at this time invisible and almost impalpable.

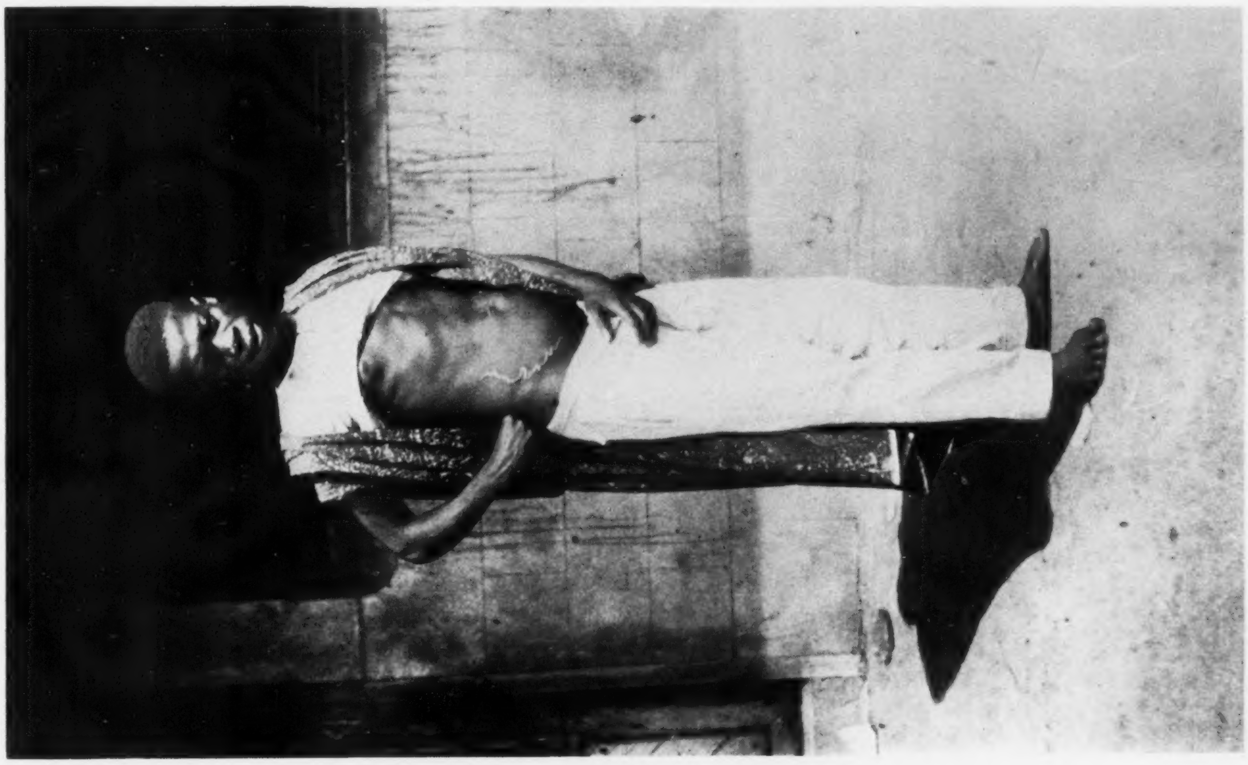

Fig. 2

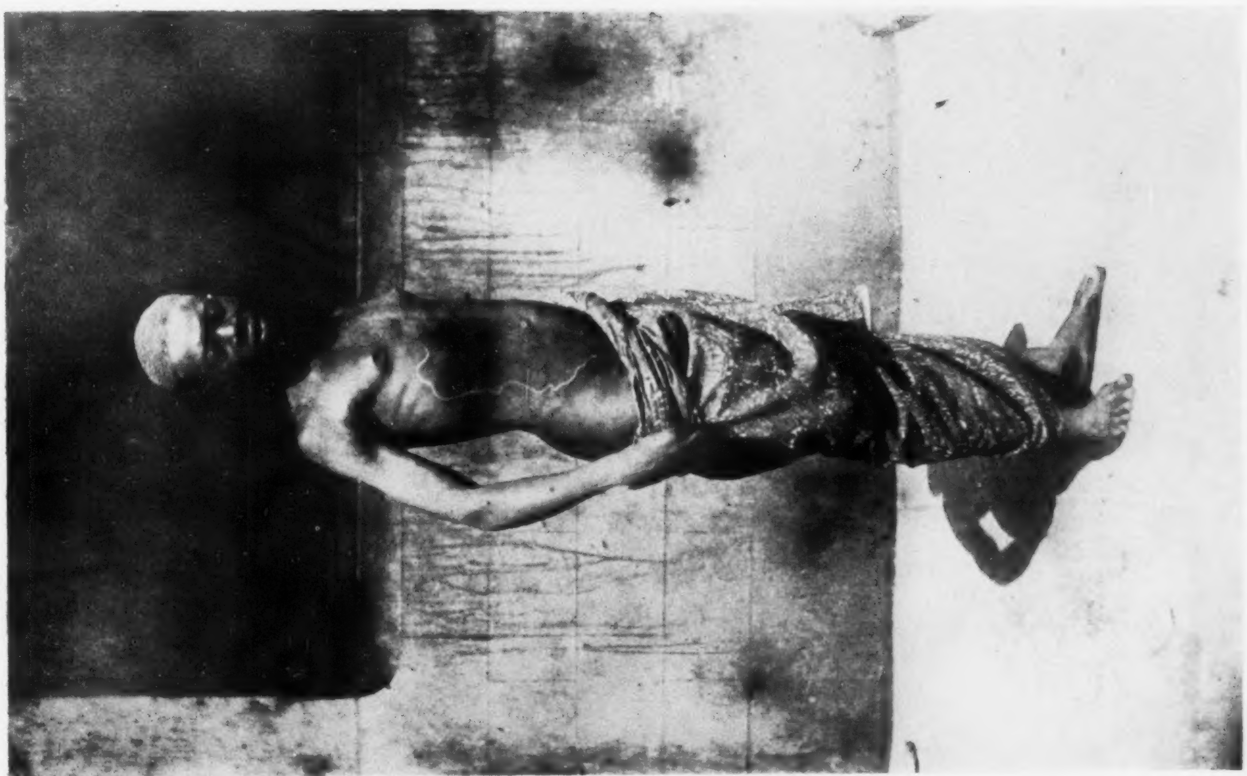

Fig. 1

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THREE CASES OF CARDIAC ANEURYSM IN NATIVE BOYS OF THE GOLD GOAST

BY

J. W. S. MACFIE

AND

A. INGRAM.

(*Received for publication* 19 *August*, 1920)

PLATE III

In this note we record in the briefest manner three cases of aneurysm of the heart in native boys of the Gold Coast, West Africa, which have come under our notice during the last four years. We have to thank Dr. H. T. Palmer, Dr. C. H. D. Ralph, and Dr. G. E. H. Le Fanu for the opportunity of examining the first, the second, and the third, respectively, and for furnishing the notes made at the autopsies, and we take this occasion of expressing our indebtedness to them.

CASE I. A native boy, aged seven years, who died suddenly in the early hours of the morning when getting from his bed. The boy was not seen before death, and no history of previous ill-health was reported by the parents.

At the autopsy the body was found to be that of a well developed boy. No macroscopical lesions were observed excepting those of the heart. The pericardium was full of blood, which had issued from a rupture, about a quarter of an inch long, in an aneurysm near the apex of the left ventricle. There were no pericardial adhesions. The cavity of the aneurysm contained well-formed fibrinous clot.

The *heart* (Plate III, fig. 2) was not hypertrophied; there was no valvular disease. At the apex of the left ventricle was a small saccular aneurysm extending on the surface from the tip of the heart downwards for about 15 mm., then outwards, and upwards on the left side for about 25 mm., and internally communicating with the

chamber of the left ventricle by a narrow opening. The aneurysm was composed of two chambers incompletely separated, a small cavity filled with fibrous clot at the very apex of the heart, and a larger cavity a little to the left side. In the photograph the larger cavity is shown after it had been laid open by a longitudinal incision. The larger cavity measured 25 mm. by 15 mm. by 15 mm., its wall was very thin, especially at its lower and anterior pole, where it had given way. The inner surface was partly covered by fibrinous clot.

Sections of the wall of the left ventricle showed a considerable degree of interstitial myocarditis. The aorta appeared to be healthy. The left coronary artery showed a slight degree of endarteritis together with some degeneration of the inner coat.

CASE II. A native boy, aged six years, who suddenly fell dead outside school. He had not been pushed or struck, and, it was stated, had never been ill nor attended by a doctor.

At the autopsy the body was found to be well nourished, without signs of injury or violence. In addition to the condition of the heart, presently to be described, there were found a few adhesions at the apex of the right lung, an enlarged spleen, and a few round worms (*Ascaris lumbricoides*) in the intestine; the organs of the body appeared to be otherwise healthy. The pericardium was full of blood clot. When this was cleared away it was seen that the blood had escaped from the heart through a small opening near the apex of the left ventricle. There were no pericardial adhesions. The posterior mediastinal glands were enlarged, and several of them contained yellow caseous matter.

The *heart* (Plate III, fig. 1) was not hypertrophied. On the left side, a little posterior to the middle of the ventricle and spreading on to the front of the heart, was a swelling nearly 30 mm. in diameter and raised about 10 mm. above the normal level of the heart, on this swelling were three distinct nodules, one anterior and two posterior. Connected with the swelling, at its lower and external margin, was a sac-like prolongation, about 17 mm. long and 14 mm. broad at its base, which projected freely on the posterior aspect of the heart; at its free margin, where the wall was very thin, was a small tear. On incising the heart it was found that the external bulgings were caused by two aneurysms, both opening a little above and to the

outer side of the apex of the left ventricle at the roots of the papillary muscles, the one anterior and the other posterior, but quite distinct. The latter had ruptured, thus bringing about the death of the boy.

At the base of the heart, lying between the ventricles just below the aortic orifice, was a rounded mass about 10 mm. in diameter which had the appearance of a gumma, both to the naked eye and in sections. The myocardium in the neighbourhood of the gumma showed a considerable increase of fibrous tissue. Sections of the wall of the left ventricle showed a slight degree of interstitial myocarditis. The left coronary artery showed a slight degree of endarteritis and degeneration of the inner coat.

CASE III. A native boy, aged twelve years, who died suddenly during a quarrel with another boy. At the autopsy it was noted that, in addition to the presence of an aneurysm of the heart, the liver and lungs showed signs of chronic inflammatory changes, and that the arteries were sclerosed. Death was due to heart failure.

The *heart* (Plate III, fig. 3) appeared to be slightly hypertrophied. With the exception of the apical portion, practically the whole of the posterior wall of the left ventricle was occupied by a convex dilatation of almost stony hardness; this dilatation formed a dome-shaped structure, with a diameter of about 40 mm. and a height of about 30 mm. In the photograph it is shown as seen from the inner aspect after the heart had been incised. The outer surface was smooth; there were no pericardial adhesions. The inner surface was irregularly studded with calcareous nodules, some of which were smooth, others very rough; it was divided by an oblique ridge of no great prominence into an upper and a lower portion. The middle part of the dome was thin and more or less translucent, and appeared to be bony.

On the aorta were numerous small patches of atheroma, which in sections showed calcification and proliferation of the inner coat. Sections of the wall of the left ventricle external to the aneurysm showed practically no fibrosis. The left coronary artery showed a slight degree of endarteritis, slighter than in either of the two preceding cases.

It is somewhat remarkable that these three cases, which are the only cases of cardiac aneurysm that we have hitherto met with in

the Gold Coast, were young boys (six to twelve years), for Legg (1883) considered that aneurysm of the heart was a 'disease of middle and advanced life, rather than a disease specially common below thirty, as Thurnam believed,' and Hall (1903) records only a solitary case under twenty, and this one due to trauma. At the time Legg wrote, the youngest case known was 'a little girl of twelve (who) died suddenly while at play from the bursting of the aneurysm.'

According to Hall, the aneurysms are nearly always single. It is interesting to note, therefore, that in these three cases, one aneurysm was bilocular, and one double. In all the three cases the aneurysms formed definite swellings or tumours on the surface of the heart, but there were no pericardial adhesions. In two of the cases the myocardium showed some degree of fibrosis, in the third no such change was apparent in the sections cut.

Death was sudden in all three cases, and, so far as could be ascertained, was not preceded by any symptoms of illness. Two of the boys died from the rupture of the aneurysm into the pericardium. In this connexion, it may be recalled that on a previous occasion (1917) attention was drawn to the fact that in the Gold Coast perforation into the pericardium of small aneurysms of the intra-pericardial aorta is not a very uncommon cause of sudden death in adult natives previously thought to be in good health and certainly capable of hard physical work.

Hall brings forward coronary endarteritis as 'the great cause of aneurysms of the left ventricle, and, with hardly any exceptions, as the sole cause of aneurysms at the apex.' The result, he says, is 'either sudden obstruction leading, if the collateral circulation is insufficient, to infarction, or gradual obstruction leading to replacement of the myocardium by fibrous tissue, which may or may not yield later to the blood pressure, and cause aneurysm,' and the most usual sequence of events 'a gradual stenosis of the artery by disease, to which is superadded thrombosis, causing sudden complete obliteration.' Particular interest, therefore, attaches to the condition of the coronary arteries in these cases. In all three the condition was similar; there was a slight degree of endarteritis together with some degeneration of the inner coat. Professor Ernest Glynn has been so kind as to examine the sections of the

arteries, and is of the opinion that the condition was not characteristic of syphilitic endarteritis, but that in view of the gumma-like tissue detected in the second case it was possibly of this nature.

Apart from the conditions of the heart, no other, or only slight macroscopic lesions were observed at the autopsies on these boys, who appeared to have been otherwise healthy, and, so far as could be ascertained, had not previously suffered from serious illness. It may be confidently assumed, however, that they had all previously suffered from malaria, and especially subtertian malaria, a disease from which probably no native child in the Gold Coast escapes. In the opinion of some authors, malarial endarteritis is a well-defined condition; Moreau (1918), for example, has recently referred to two cases of gangrene of the lower extremities, which he believed were the result of posterior tibial endarteritis, due to malaria. It is possible that the endarteritis in these cases of cardiac aneurysm was due to malaria, but further work on the pathology of the disease is necessary before this connexion can be established.

Obstruction of the arterioles is, however, admitted to be common in malaria, especially subtertian malaria, and to be the cause of many and varied complications. Dudgeon and Clarke (1917), in a recent study of the microscopical histology of malaria, remark that 'this vascular obstruction would seem to be most marked in the brain, spleen, and heart muscle.' The same authors found in all the six cases they examined fatty degeneration of the heart muscle, a condition which Legg considered 'certainly deserves attention as a cause of aneurysm.' If Hall is correct in attributing to coronary obstruction the chief part in the causation of aneurysms of the left ventricle, there seems no reason why such aneurysms should not be due to malaria.

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FIG. 1

FIG. 2

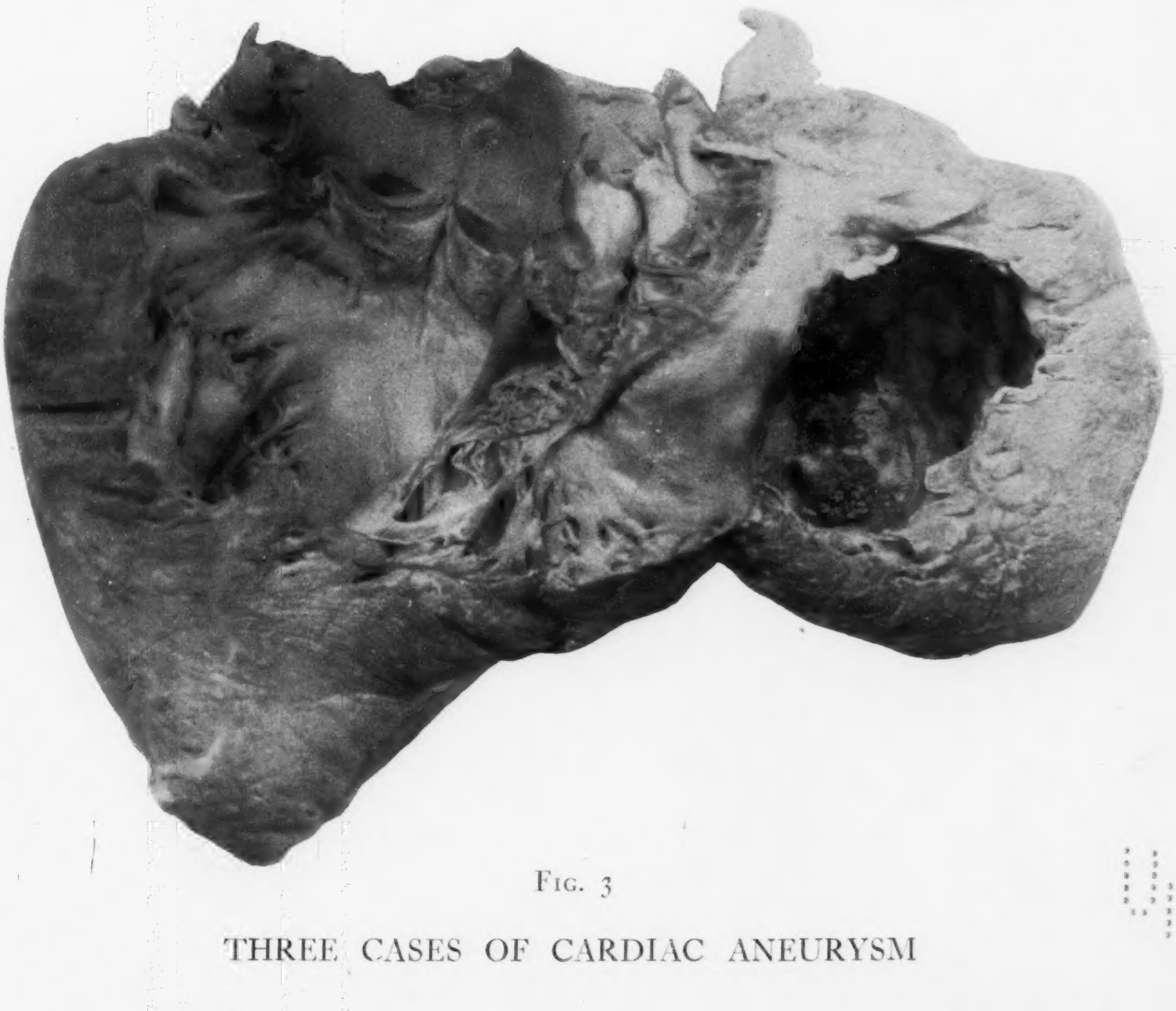


FIG. 3

THREE CASES OF CARDIAC ANEURYSM

Photographs by Alex. A. Randolph, Accra *C. Tinling & Co., Ltd., Imp.*

STRONGYLIDAE IN HORSES

IX. *CYLICOSTOMUM TRIDENTATUM* sp. n.

BY

WARRINGTON YORKE

AND

J. W. S. MACFIE

(*Received for publication* 13 *August*, 1920)

This worm was found in the caecum and colon of a young mule at Accra in the Gold Coast, West Africa, and in a horse in Jamaica.

SIZE AND SHAPE. A moderately small species of the Genus *Cylicostomum*. Eight females and eight males were measured. The males measured 7 mm. to 7·5 mm. in length, average 7·25 mm.; the females from 7·6 mm. to 9·75 mm., average 9·2 mm. The greatest breadth in the worms, when properly orientated, averaged in the males 307μ, and in the females 450μ.

HEAD. A well-marked neck separates the head from the body.

Mouth collar. Marked off from the rest of the skin by a definite constriction.

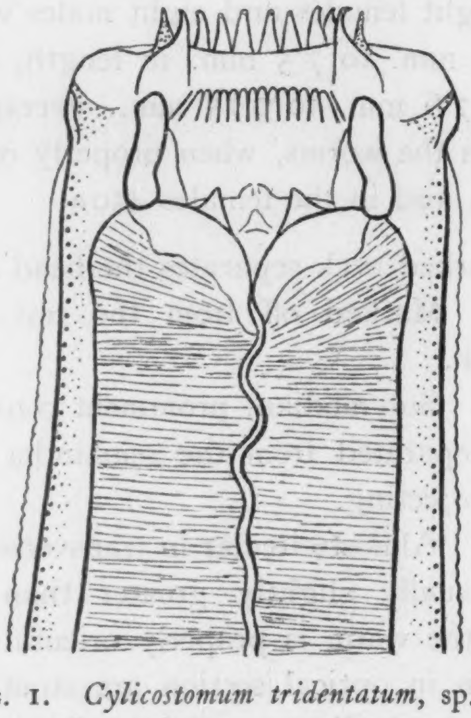
Head papillae. Sub-median, prominent conical and projecting, their extremities separated from the remainder by a constriction; lateral, scarcely projecting.

Mouth capsule. Almost circular in transverse section, the lateral diameter being usually slightly greater than the dorso-ventral diameter. When the worm is properly orientated the walls of the mouth capsule seen in optical section are stout, of approximately uniform thickness, and diverge slightly from before backwards. (fig. 1). When viewed laterally the walls of the buccal capsule have a similar appearance, and also diverge slightly from before backwards. In properly orientated worms the antero-posterior diameter (*i.e.*, the distance from the anterior to the posterior opening) of the buccal capsule varied in the males from 24μ to 29μ, average 26μ, and in the females from 29μ to 34μ, average 32·3μ. In the males the lateral diameter of the buccal capsule at the anterior

opening was 40μ to 41μ, and at the posterior opening 50μ; in the females the lateral diameter of the buccal capsule at the anterior opening varied from 48μ to 54·5μ, average 52·6μ, and at the posterior opening from 55μ to 66·5μ, average 59·6μ. The ratio of the lateral diameter of the buccal capsule at the anterior opening to the antero-posterior diameter is in both sexes about 1·5 to 1.

Dorsal oesophageal gutter. Projects into the buccal capsule as a small tubercle.

Leaf crowns. The external leaf crown consists of about twenty large pointed elements arising from the mouth collar. The internal leaf crown consists of about thirty-six rather long, moderately broad elements, having a pallisade-like appearance arising in a single plane within the mouth capsule near its anterior opening (fig. 1).



A. M. B., del.

FIG. 1. *Cylicostomum tridentatum*, sp. n.
Anterior extremity, ventral view. × 360.

OESOPHAGUS. The length in the males was 370μ to 384μ, average 376μ, and the greatest breadth 104μ to 115μ, average 109μ, the ratio of breadth to length was 1 to 3·5. In the females the length ranged from 445μ to 519μ, average 481μ, and the greatest breadth from 130μ to 133μ, average 131μ; the ratio of breadth to length was 1 to 3·8. The ratio of the length of the oesophagus to that of

the worm was, in the male 1 to 19·2, and in the female 1 to 19·1. The chitinised oesophageal funnel is well developed; corresponding to the three divisions of the oesophagus are three small pointed

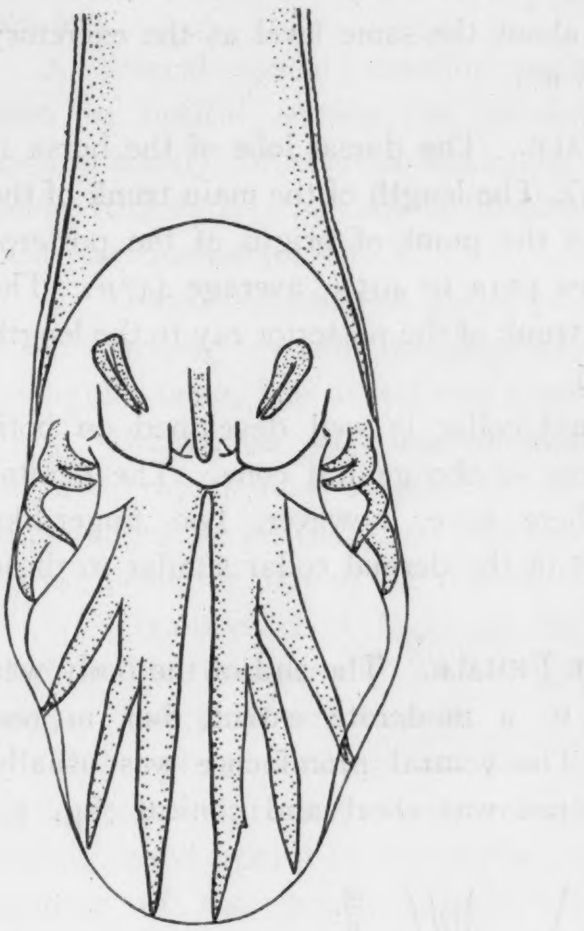


FIG. 2.

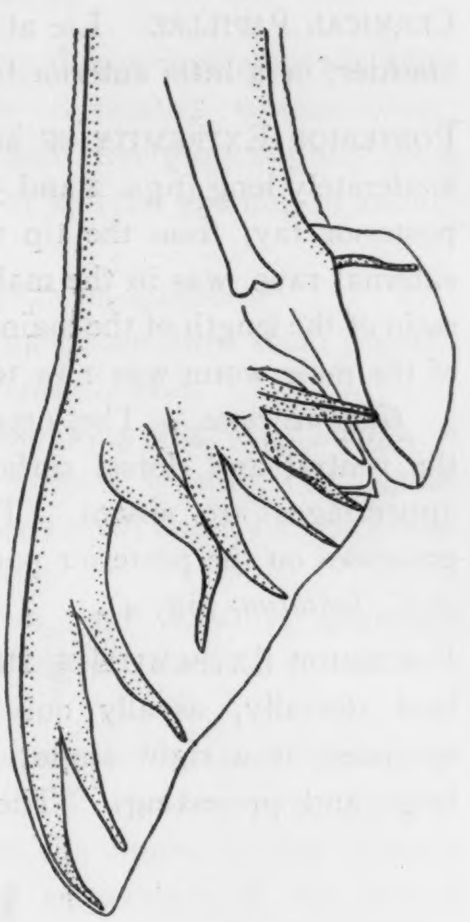


FIG. 3.

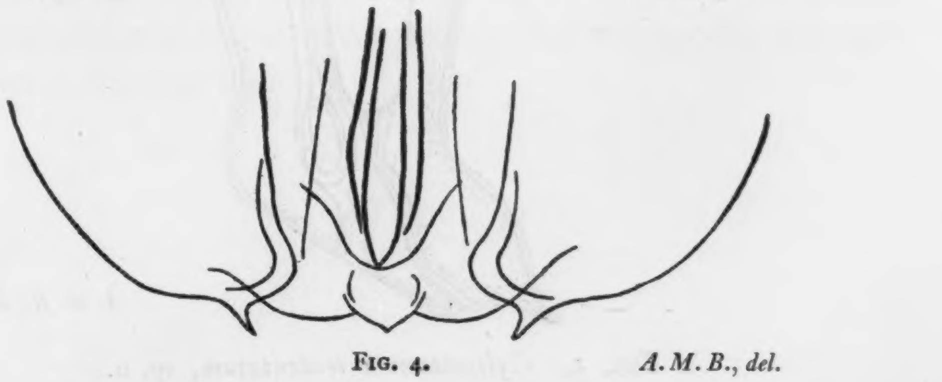


FIG. 4. *A. M. B., del.*

FIGS. 2-4. *Cylicostomum tridentatum*, sp. n.
FIG. 2. Posterior extremity of male, ventral view. × 90.
FIG. 3. Posterior extremity of male, lateral view. × 90.
FIG. 4. Genital cone, ventral view. × 360.

triangular teeth projecting from the oesophageal funnel into the mouth capsule, one dorsal and two ventro-lateral.

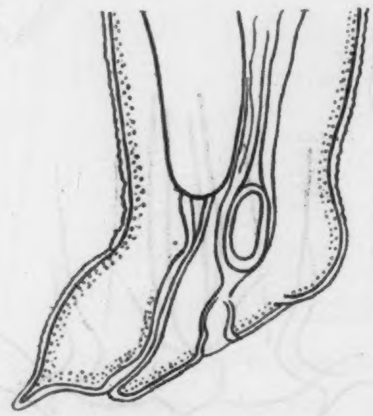
EXCRETORY BLADDER. Lies a little behind the nerve ring. The distance of its posterior margin from the posterior end of the oesophagus varied from 96μ to 140μ, average 114μ.

CERVICAL PAPILLAE. Lie at about the same level as the excretory bladder, or a little anterior to it.

POSTERIOR EXTREMITY OF MALE. The dorsal lobe of the bursa is moderately long (figs. 2 and 3). The length of the main trunk of the posterior ray, from the tip to the point of origin of the postero-external rays, was in the males 420μ to 495μ, average 447μ. The ratio of the length of the main trunk of the posterior ray to the length of the male worm was 1 to 16.

Genital cone. The dermal collar is well developed on both the ventral and dorsal surfaces of the genital cone. The genital appendages are absent. There were, however, two finger-like processes on the posterior part of the dermal collar similar to those in *C. labiatum* (fig. 4).

POSTERIOR EXTREMITY OF THE FEMALE. The end of the body was bent dorsally, usually only to a moderate extent, but in one specimen at a right angle. The ventral prominence was usually large and projecting. The tail was short and conical (fig. 5).



A. M. B., del.

FIG. 5. *Cylicostomum tridentatum*, sp. n.

Posterior extremity of female, lateral view. × 90.

The distance between the anus and vulva varied from 102μ to 151μ, average 118μ, and the distance measured straight along the middle line of the tail, from the tip to a line drawn horizontally through the anus, varied from 95μ to 108μ, average 100μ.

DIAGNOSIS. The following are the chief diagnostic characters of the worm:—

1. Size, moderately small; length, male 7·25 mm. and female 9·2 mm.

2. Buccal capsule: anterior opening almost circular; walls when seen in optical section, in properly orientated worms, stout, approximately uniform in thickness, and diverging slightly from before backwards; the ratio of breadth at anterior opening to antero-posterior diameter 1·5 to 1.

3. Dorsal oesophageal gutter projects as a tubercle.

4. Arising from the oesophageal funnel are three small pointed triangular teeth, one dorsal and two ventro-lateral.

5. Dorsal lobe of bursa moderately long; ratio of length of posterior ray to total length of male worm 1 to 16. The genital appendages are absent; there are, however, two finger-like processes on the posterior part of the dermal collar.

6. Termination of body of female bent dorsally, generally slightly but occasionally at a right angle. Ventral prominence large. Tail short and conical.

This species belongs to the *catinatum-alveatum* group of Cylicostomes. It most closely resembles *C. alveatum*, but may be distinguished from it by its smaller size, the almost circular anterior opening of the mouth capsule, the projection of the dorsal oesophageal gutter as a tubercle, and by the three small teeth arising from the oesophageal funnel. We propose for this species the name *Cylicostomum tridentatum*.

DIAGNOSIS.—The following are the most diagnostic characters of the species:—

1. Size, moderately small: [illegible] [illegible] mm. and breadth 0.7 mm.

2. Buccal capsule: anterior opening almost circular; walls, when seen in optical section, in properly orientated worms, about approximately uniform in thickness, and converging slightly from before backwards; the ratio of [illegible] to [illegible] of the opening to [illegible] diameter [illegible].

3. Dorsal oesophageal gutter [illegible] as a [illegible].

4. Arising from the oesophageal funnel are three small [illegible] triangular teeth, one dorsal and two [illegible].

5. Dorsal lobe of bursa moderately [illegible] ratio of length of [illegible] [illegible] to final length of male worm [illegible] to [illegible]. The genital [illegible] are absent; there are, however, two [illegible] processes on the posterior part of the [illegible].

6. Termination of body of female [illegible] [illegible] [illegible] at an [illegible] angle [illegible] large. Tail short and conical.

This species belongs to the [illegible] group of Cylicostomes. It most closely resembles C. [illegible], but may be distinguished from it by its smaller size, the [illegible] opening of the mouth capsule, the [illegible] of the dorsal oesophageal gutter as a tubercle, and by the [illegible] teeth arising from the oesophageal funnel. We propose for this species the name Cylicostomum [illegible].

STRONGYLIDAE IN HORSES

X. ON THE GENUS *POTERIOSTOMUM*, Quiel

BY

WARRINGTON YORKE

AND

J. W. S. MACFIE

(*Received for publication 2 September*, 1920)

In 1919, Quiel described a Strongyle (*Poteriostomum imparidentatum*) found in the caecum and colon of horses at Donchery, which, although closely resembling a Cylicostome, differed from members of this genus in certain respects. For this worm he erected the genus *Poteriostomum*, which he defined as follows:—A sclerostome genus with a well developed internal leaf crown, most closely related to the genus *Cylichnostomum*, Looss, but distinguishable from the latter by the fact that the six leaves of the inner leaf crown lying in the radii of the head papillae are differentiated from the others by their greater length and by their distinct shape, and by the fact that there are no bosses at the posterior end of the female. Quiel called this worm *P. imparidentatum*. A little later the same worm was discovered independently in Dutch horses by Ihle (1920), who also created a new genus for it and gave it the name *Hexodontostomum markusi*, and in a Chapman's zebra by Turner (1920) who called it *Cylichnostomum zebrae*.,

Shortly before the appearance of Quiel's paper, Kotlán had

described a Strongyle found in Hungarian horses which bears a close resemblance to Quiel's *Poteriostomum*, but differs from it in that all the elements of the internal leaf crown are of the same size. To this parasite Kotlán gave the name *Cylichnostomum ratzii*. This worm was subsequently found by Ihle (1920) in Dutch horses.

Both the above worms were found by us in material obtained from a young mule at Accra in the Gold Coast. On comparing them we were at once impressed with their close resemblance; *C. ratzii* differing from *P. imparidentatum* chiefly by the character of the internal leaf crown, the elements of which were in *C. ratzii* of equal size and furnished with pointed tips, and in *P. imparidentatum* of unequal size (those corresponding to the head papillae being longer and pointed) and having rounded ends.

We were particularly impressed by the fact that the bursae were similar and differed markedly from those found in any hitherto described species of the genus *Cylicostomum*. Ihle has given an admirable description of this structure; he points out that the supporting rays form two distinct groups, an antero-median and a posterior. It is in the character of the posterior group that the bursa chiefly differs from that of Cylicostomes; the postero-external ray arises from a common trunk with the posterior, the main trunk of the posterior ray is not split to the base, but only for about half its length, the two lateral branches arising from the undivided portion close to the point of origin of the postero-external rays. These characters are clearly shown in figs. 1 to 6.

This arrangement of the posterior rays of the bursa appears to us to warrant the separation of both the worms from the genus *Cylicostomum*; whereas the slight difference in the characters of the internal leaf crown of the two worms, which is much less than that exhibited by such Cylicostomes as *C. radiatum*, Looss, and *C. bicoronatum*, Looss, does not, in our opinion, justify placing them in different genera. We, therefore, propose to regard both worms as belonging to the genus *Poteriostomum*, and suggest that the definition of the genus be emended to include all Cylicostome-like worms having the bursal characters described above.

Accepting this definition of the genus, the following worms must then be included in it:—

Poteriostomum imparidentatum, Quiel, 1919 (syn. *Hexodontostomum markusi*, Ihle, 1920, and *Cylichnostomum zebrae*, Turner, 1920.

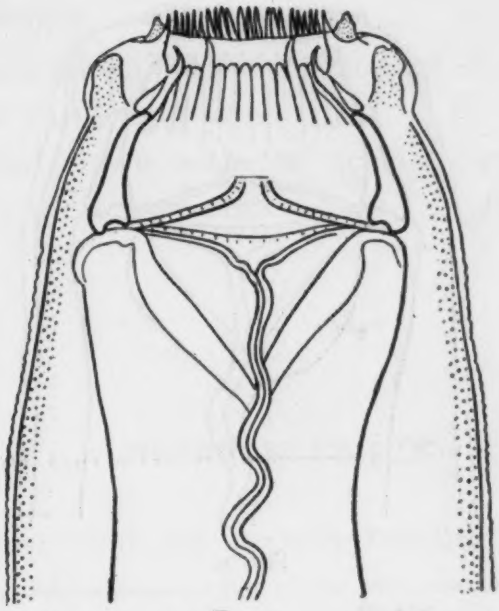


FIG. 1.

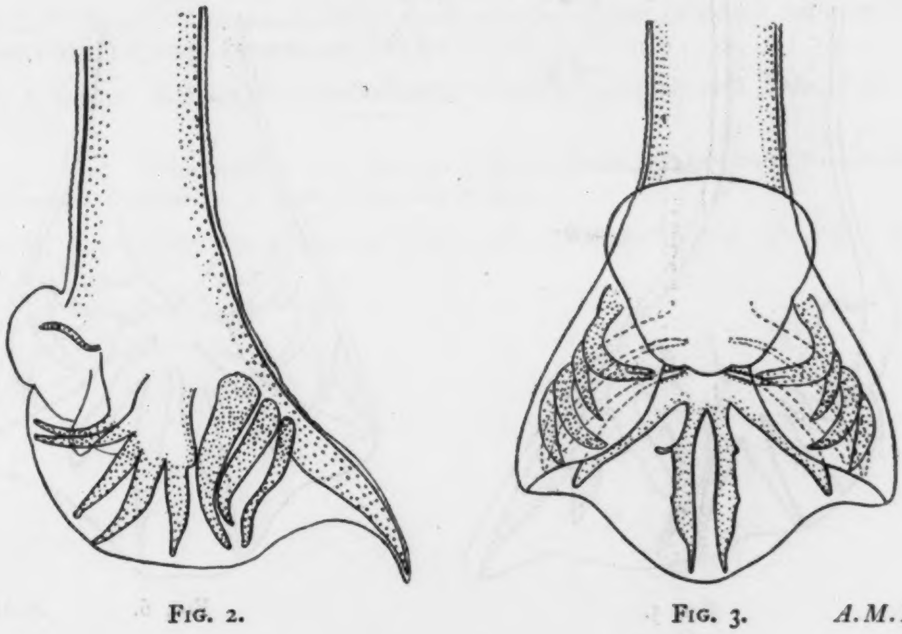


FIG. 2.   FIG. 3.   *A.M.B., del.*

Poteriostomum imparidentatum, Quiel.

FIG. 1. Anterior extremity, ventral view. × 180.
FIG. 2. Posterior extremity of male, lateral view. × 45.
FIG. 3. Posterior extremity of male, ventral view. × 45.

Poteriostomum pluridentatum, Quiel, 1919.

Poteriostomum ratzii (Kotlán), 1919. (syn. *Cylichnostomum ratzii*, Kotlán, 1919.

Perhaps *Cylicostomum ultrajectimum*, Ihle, 1920, also belongs this genus, but as only a single female has so far been found, it is impossible to say.

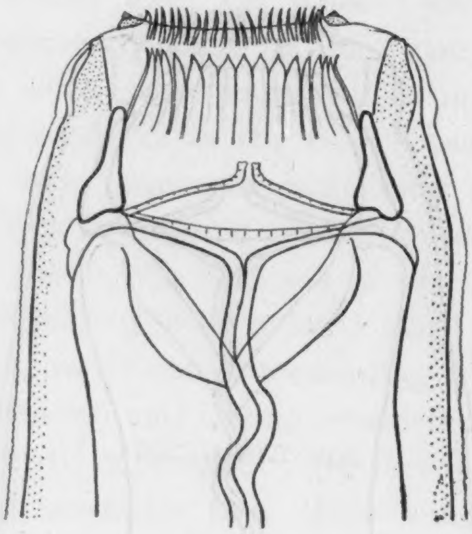


FIG. 4.

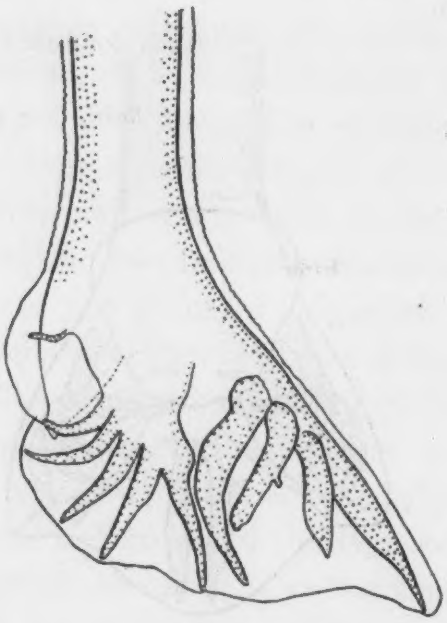


FIG. 5.

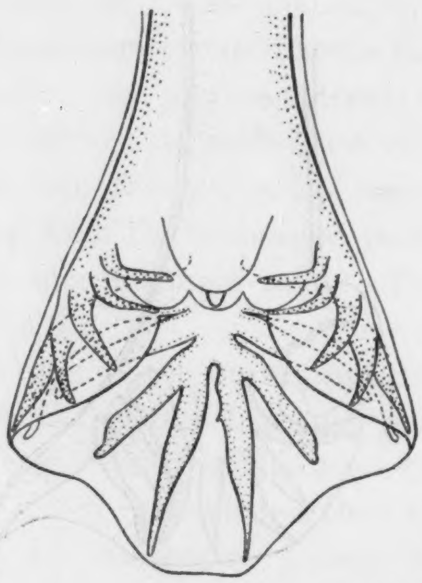


FIG. 6.

A. M. B., del.

Poteriostomum ratzii, (Kotlán).

FIG. 4. Anterior extremity, ventral view. × 180.
FIG. 5. Posterior extremity of male, lateral view. × 45.
FIG. 6. Posterior extremity of male, ventral view. × 45.

The species of the Genus *Poteriostomum* hitherto described may be distinguished as follows:—

1. All the elements of the internal leaf crown of equal length ... ... *P. ratzii.*
   Elements of the internal leaf crown not all of equal length 2
2. Internal leaf crown with seven normal elements between the longer ones ... *P. imparidentatum.*
   Internal leaf crown with ten normal elements between the longer ones ... *P. pluridentatum.*

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STRONGYLIDAE IN HORSES

XI. SPECIES FOUND IN WEST AFRICA AND JAMAICA

BY

WARRINGTON YORKE

AND

J. W. S. MACFIE

(*Received for publication 2 September, 1920*)

Species found in West Africa

The material to which this note relates was obtained from three horses and one young mule bred in West Africa; one of the horses was examined at Ilorin in Nigeria, and one at Tamale in the Northern Territories of the Gold Coast, and the other two animals at Accra. We are indebted to Dr. K. B. Allan for very kindly sending us the specimens from Tamale.

The horse and the young mule examined at Accra had been condemned to be shot because of their poor condition. They were both very weak, greatly emaciated, and apparently dying. At the post-mortem examinations, which were made by one of us, numerous *Strongylidae* were found in the caecum and colon of both animals, and in the young mule particularly there were vast numbers of them. No other cause was found to account for the sickness of the animals, blood examination was negative, and it was therefore concluded that their condition was due to infection with these worms. The horse examined at Ilorin had died of trypanosomiasis.

In the following table a list is given of the species of *Strongylidae* found in each animal.

	Young Mule: Accra, Gold Coast.	Horse: Accra, Gold Coast.	Horse: Tamale, Gold Coast.	Horse: Ilorin, Nigeria.
Strongylus.				
S. edentatus, Muller, 1784	+	+	+	+
S. equinus, (Looss), 1900	...	+	...	...
S. vulgaris, (Looss), 1900	+	+	...	+
Triodontophorus				
T. intermedius, Sweet, 1908	+	+	...	...
T. minor, Looss, 1900	+	+	...	...
Cylicostomum				
C. alveatum, Looss, 1900	...	...	...	+
C. catinatum var. *litoraureum*, var. n.	...	...	+	...
C. coronatum, Looss, 1900	+	...	+	+
C. insigne, Boulenger, 1917	+	...	...	...
C. labiatum, Looss, 1901	+	...	...	...
C. longibursatum, Yorke and Macfie, 1918	+	...	...	...
C. nassatum, Looss, 1900	...	...	+	+
C. nassatum var. *parvum*, Yorke and Macfie, 1918	+	...	...	...
C. poculatum, Looss, 1900	+	...	...	...
C. pseudo-catinatum, Yorke and Macfie, 1919	+	...	...	...
C. radiatum, Looss, 1900	+	...	...	...
C. tridentatum, Yorke and Macfie, 1920	+	...	...	...
Poteriostomum				
P. imparidentatum, Quiel, 1919	+	...	...	...
P. ratzii, (Kotlán), 1919	+	...	...	...

One of the above species requires special mention, viz. :—

Cylicostomum catinatum var. *litoraureum*, var. n.

This worm was obtained from the caecum and colon of a horse

at Tamale in the Northern Territories of the Gold Coast, West Africa.

One male and seven females were found. The length of the male was 9 mm.; the lengths of the females ranged from 8·75 mm. to 12 mm., average 9·9 mm.

The worm was indistinguishable from *C. catinatum*, Looss, excepting by the characters of the appendages of the genital cone, which exhibited a striking difference. As is shown in fig. 2, the

FIG. 1.

A. M. B., del.

FIG. 2.

FIG. 1. *Cylicostomum catinatum*, Looss.
Genital appendages, ventral view (after Looss). × 360.

FIG. 2. *Cylicostomum catinatum* var. *litoraureum*, var. n.
Genital appendages, ventral view. × 360.

appendages of this worm consisted of two long finger-like processes, each bearing a tubercle on its inner aspect and a short process between them, whereas, according to Looss, the appendages of the genital cone of *C. catinatum* consist of 'medium long processes with notched outlines and rounded extremities.'

We regard this worm as a variety of *C. catinatum*, Looss, and propose to call it *Cylicostomum catinatum* var. *litoraureum*.

Species found in Jamaica

Material from one horse was examined, and the following species identified:—*C. euproctus*, *C. longibursatum*, *C. nassatum* var. *parvum*, and *C. tridentatum*.

at Tagulu in the Northern Territories of the Gold Coast, West Africa.

One male and eleven females were found. The length of the male was 9 mm.; the lengths of the females ranged from 8·75 mm. to 12 mm., average 9·7 mm.

The worm was indistinguishable from *C. radiatum*, Looss, excepting for the characters of the appendages of the genital cone, which exhibited a striking difference. As is shown in fig. 4, the

FIG. 4.—[illegible] *radiatum*, [illegible]
[illegible]
[illegible]
[illegible]

appendages of this worm possessed two long finger-like processes, each having a tubercle on its inner aspect, and a short process between them, as shown in fig. 4 *a*, *b*, while the appendages of the genital cone of *C. radiatum* consist of two [illegible] processes with [illegible] and rounded extremities.

We regard this worm as a variety of *C. radiatum*, Looss, and propose to call it *Cylicostomum radiatum* var. [illegible].

Species found in *Zungeru*.

Material from one horse was examined, and the following species identified:—*C. [illegible]*, *C. [illegible]*, *C. [illegible]* var. *[illegible]*, and *C. [illegible]*.

STRONGYLIDAE IN HORSES

XII. *CYLINDROPHARYNX RHODESIENSIS* sp. n.

BY

WARRINGTON YORKE

AND

J. W. S. MACFIE

(*Received for publication* 20 *September*, 1920)

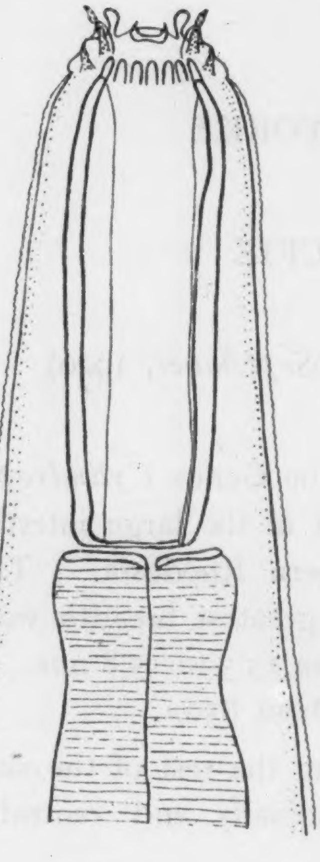
SIZE AND SHAPE. A large species of the Genus *Cylindropharynx*. One male and four females were found in the large intestine of a zebra (*Equus burchelli*) shot in Northern Rhodesia. The male measured 12·5 mm. in length and its greatest breadth was about 650μ. The females varied in length from 13·5 to 15·8 mm., average 14·6 mm.; their greatest breadth was about 830μ.

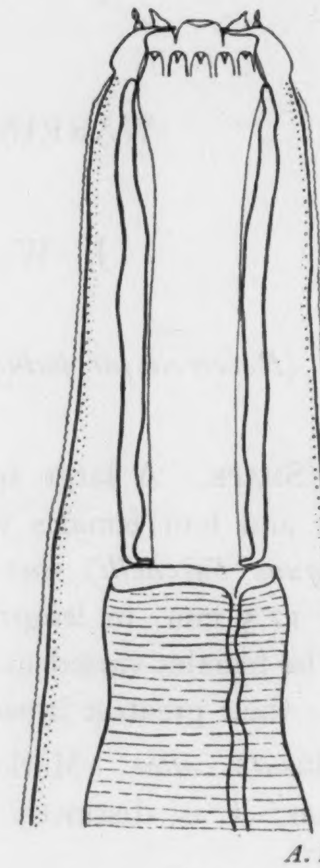
HEAD. *Mouth collar*. Marked off from the rest of the skin by a constriction; it is distinctly higher dorsally and ventrally than laterally.

Head papillae. Sub-median, large and prominent, the distal, spindle shaped, portion being separated off from the proximal, conical, portion by a constriction. Lateral, not conspicuous, scarcely projecting.

Mouth capsule. Exhibits the great length characteristic of the Genus (fig. 1). It is almost circular in transverse section, the dorso-ventral diameter being slightly greater than the lateral. The antero-posterior diameter was in the male 520μ, and in the females varied from 511μ to 544μ, average 526μ. The greatest dorso-ventral diameter was in the male 144μ, and in the females varied from 175μ to 178μ, average 177μ. The greatest lateral diameter was in the male 138μ, and in the females varied from 161μ to 165μ, average 164μ. The ratio of the greatest breadth to the length of the mouth capsule was in the male 1 to 3·8, and in the females 1 to 3·2. The

walls of the mouth capsule are stout, of almost uniform thickness except at the two extremities, where they taper slightly: they are almost parallel, the greatest diameter is found near the anterior opening (figs. 1 and 2).





A. M. B., del.

FIG. 1. FIG. 2.

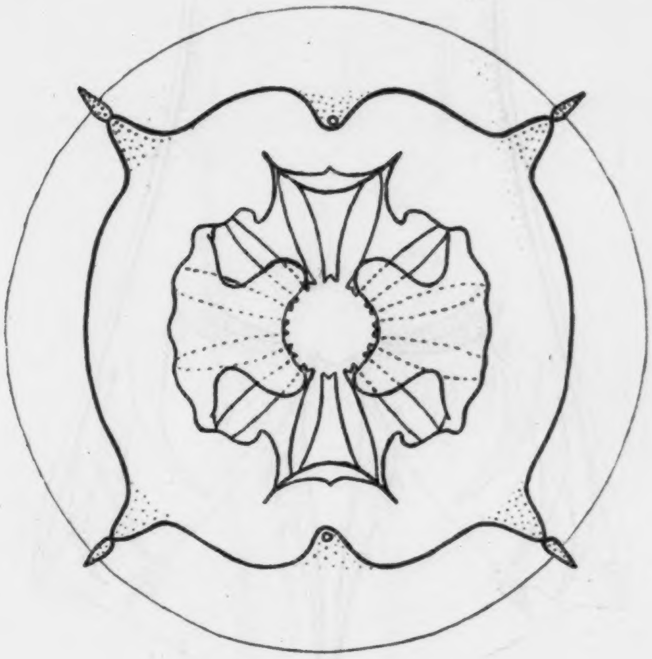
Cylindropharynx rhodesiensis, sp. n.

FIG. 1. Anterior extremity, ventral view. × 90.
FIG. 2. Anterior extremity, lateral view. × 90.

Dorsal oesophageal gutter. Does not project into the buccal capsule.

Leaf crowns. The external leaf crown consists of six large teeth corresponding in position to the head papillae. The four occupying the sub-median positions are somewhat smaller than the two situated laterally, which are also much broader. Dorsally and ventrally the external leaf crown is deficient, but from each of the prominent dorsal and ventral lips of the mouth collar there projects horizontally inwards a broad crescentic plate, the free, concave

margin of which is directed towards the axis of the mouth (see fig. 3). The internal leaf crown arises from the anterior extremity of the mouth capsule. It consists of twelve large teeth.



Cylindropharynx rhodesiensis, sp. n.

FIG. 3. End on view of anterior extremity. × 360.

OESOPHAGUS. The oesophagus is short and broad. The nerve ring is situated near the anterior extremity. The length was in the male 767 μ, and in the females varied from 833 μ to 841 μ, average 838 μ.

EXCRETORY BLADDER. Lies near the posterior end of the oesophagus.

CERVICAL PAPILLAE. Lie in front of the excretory bladder, about half-way between the nerve ring and the posterior end of the oesophagus.

POSTERIOR EXTREMITY OF THE MALE. The dorsal lobe of the bursa is short. The posterior ray exhibits the following characters: it is split to its base, and from each limb arises one lateral branch close to the point of origin of the postero-external ray, the extremity of the lateral branch bifurcates into two finger-like processes, the

external of which is slightly the longer. The main trunks of the posterior ray taper to very fine points (fig 4).

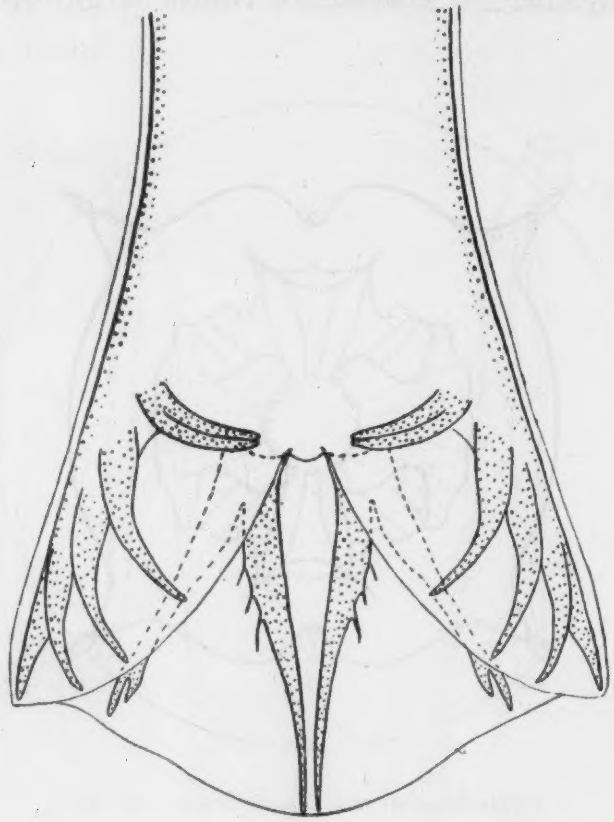
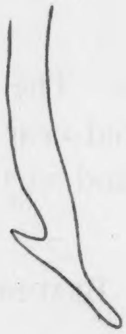


FIG. 4.



A. M. B., del.

FIG. 5. FIG. 6.

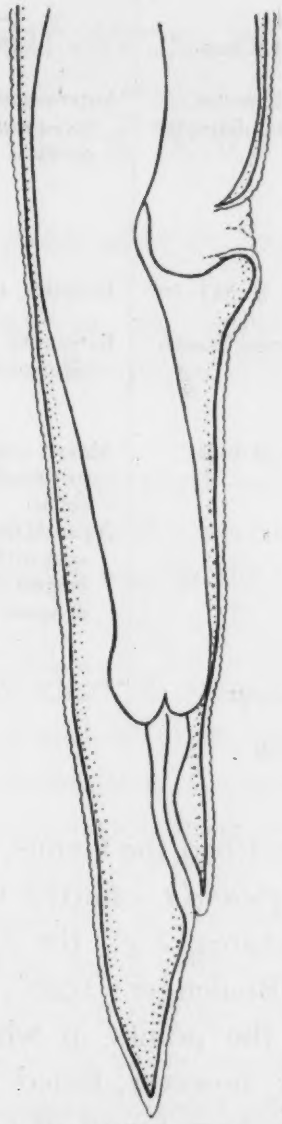
Cylindropharynx rhodesiensis, sp. n.

FIG. 4. Posterior extremity of male, ventral view. × 90.
FIG. 5. Spicules, ventral view. × 360.
FIG. 6. Spicules, lateral view. × 360.

Genital cone. The genital cone is globular. The dermal collar surrounds the cone, but is especially well developed on the ventral surface. The genital appendages appear to be absent. The spicules are long, stout and barbed, as shown in figs. 5 and 6.

POSTERIOR EXTREMITY OF THE FEMALE. The end of the body is

straight and gradually tapers to a point (fig. 7). The distance from the anus to the tip of the tail varies from 388μ to 480μ, average 417μ; and that from the vulva to the tip of the tail from 1,700μ to 2,196μ, average 1,897μ.



A. M. B., del.

Cylindropharynx rhodesiensis, sp. n.

Fig. 7. Posterior extremity of female. × 45.

DIAGNOSIS. This worm differs from the other two known species of the genus by its much greater size, and may be further distinguished by the large size of its mouth capsule and by certain details of the posterior ends of both male and female. We propose for this worm the name *Cylindropharynx rhodesiensis*. For purposes of comparison these differences are shown in the table.

	Cylindropharynx rhodesiensis Yorke and Macfie, 1920	*Cylindropharynx brevicauda* Leiper, 1911	*Cylindropharynx longicauda* Leiper, 1911
1. Length, ♂	12·5 mm.	5—7·3 mm.	4·7—5·8 mm.
♀	13·5—15·8 mm.	5·6—8 mm.	6·2—7 mm.
2. Mouth capsule	Antero-posterior diameter 511-544μ, Lateral diameter 138-165μ	Antero-posterior diameter 300-400μ, Lateral diameter 90-120μ	Antero-posterior diameter 180-200μ, Lateral diameter 70-90μ
3. Elements of the leaf crowns :			
External	—	—	—
Internal	—	—	—
4. Oesophagus	Length : ♂ 767, ♀ 833 to 841μ	Length : 470-530μ	Length : 420-450
5. Posterior extremity of male : Posterior ray	Extremity of external branch bifurcated	Extremity of external branch bifurcated	Extremity of external branch undivided or with only a minute process
Genital cone	Shorter and more globular	Almost cylindrical, completely surrounded by dermal collar	Shorter and more globular
Genital appendages ...	Apparently absent	A pair of finger-shaped appendages with rounded ends and behind them a number of delicate pointed processes	A single pair of rather stout finger-shaped processes
6. Posterior extremity of female :			
Distance of vulva from tip of tail	1700-2196μ	450-750μ	1100-1200μ (Leiper 1550μ)
Distance of anus from tip of tail	388-480μ	150-200μ	280μ (Leiper 320μ)

Leiper (1911), who described the Genus, and also the two species *C. brevicauda* and *C. longicauda*, omitted to give a full description of certain important structures, *e.g.*, the oral leaf crowns and the genitalia of the males. Boulenger (1920), in a recent paper, has supplied information on the points in which Leiper's description was deficient. Boulenger, however, failed to draw attention to the horizontal plates which we have found in *C. rhodesiensis* to project from the dorsal and ventral lips of the mouth collar. These plates are not peculiar to *C. rhodesiensis*, but were also seen by us in *C. brevicauda*, and it is probable that they are a generic character.

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STRONGYLIDAE IN HORSES

XIII. *CYLICOSTOMUM TRIRAMOSUM* sp. n.

BY

WARRINGTON YORKE

AND

J. W. S. MACFIE

(*Received for publication* 20 *September*, 1920)

This worm was found in the intestine of a zebra (*Equus burchelli*) shot in Northern Rhodesia. One male and one female were found.

SIZE AND SHAPE. A moderate sized species of the genus *Cylicostomum*. The male and female each measured 12·3 mm. in length. The greatest breadth was in the male about 630μ, and in the female about 750μ.

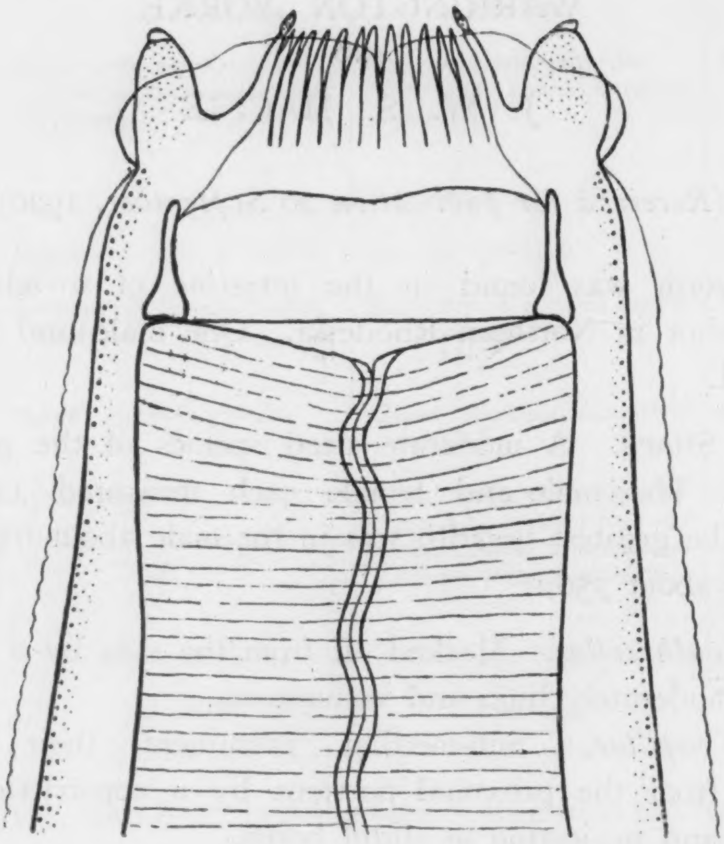
HEAD. *Mouth collar.* Marked off from the skin by a slight constriction; moderately high and voluminous.

Head papillae. Sub-median, prominent, their extremities separated from the proximal portions by a constriction; lateral, prominent and projecting as slight horns.

Mouth capsule. Ellipsoidal in transverse section, the ratio of the lateral diameter to the dorso ventral diameter at the anterior opening of the buccal capsule being as 1·2 to 1. When the worm is properly orientated the walls of the mouth capsule seen in optical section are straight, moderately slender anteriorly and stouter with a hoop-like thickening posteriorly (fig. 1). In the properly orientated worm the antero-posterior diameter (*i.e.*, the distance from the anterior to the posterior opening) of the buccal capsule was 38μ. The lateral diameter of the buccal capsule at the anterior opening was 110μ, and the dorso-ventral diameter 90μ. The ratio of the lateral diameter of the buccal capsule at the anterior opening to the antero-posterior diameter is about 2·75 to 1.

Dorsal oesophageal gutter. Does not project into the buccal capsule.

Leaf crowns. The external leaf crown consists of at least thirty large pointed elements arising from the mouth collar. The internal leaf crown consists of numerous minute elements arising from the anterior margin of the mouth capsule.



A. M. B., del.

FIG. 1. *Cylicostomum triramosum*, sp. n.
Anterior extremity, ventral view. × 360.

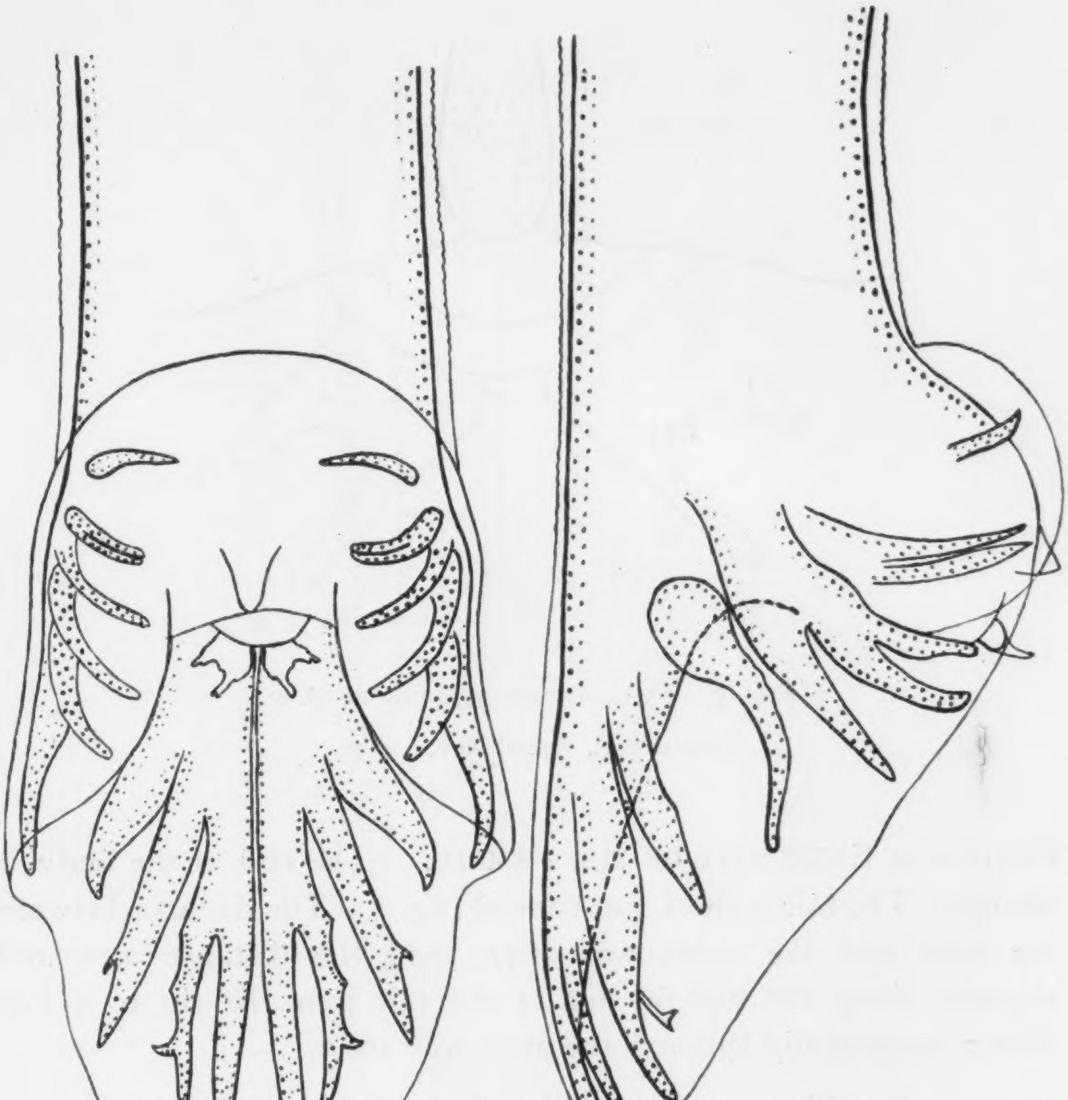
OESOPHAGUS. The length in the male was 840μ, and in the female 940μ. The ratio of the length of the oesophagus to that of the worm is in the male 1 to 14·6, and in the female 1 to 13·1.

EXCRETORY BLADDER. Lies just behind the nerve ring.

CERVICAL PAPILLAE. Lie at about the same level as the excretory bladder.

POSTERIOR EXTREMITY OF THE MALE. The dorsal lobe of the bursa is of moderate length. The length of the main trunk of the posterior ray, from the tip to the point of origin of the postero-external rays,

was 635μ. The ratio of the length of the main trunk of the posterior ray to the length of the male worm is as 1 to 20. The posterior ray gives off three lateral branches, the upper two of which arise close together (figs. 2 and 3).



A. M. B., *del.*

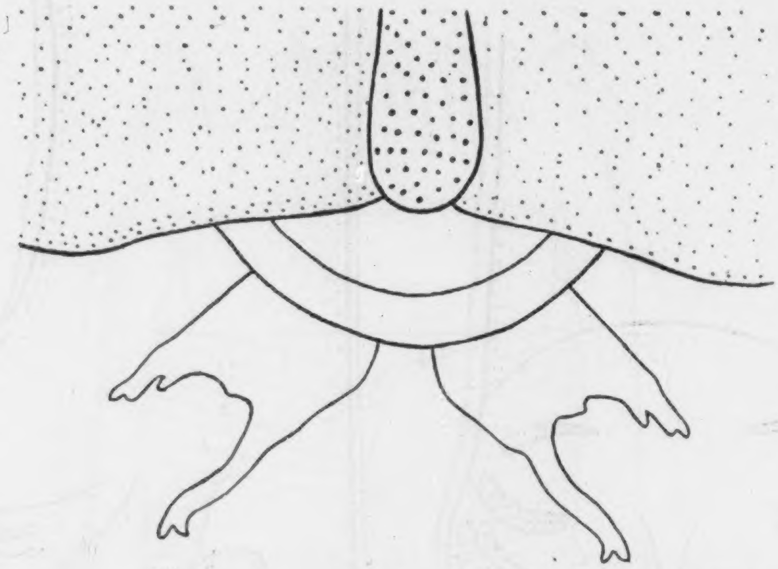
FIG. 2. FIG. 3.

FIGS. 2-3. *Cylicostomum triramosum*, sp. n.

FIG. 2. Posterior extremity of male, ventral view. × 90.
FIG. 3. Posterior extremity of male, lateral view. × 90.

Genital cone. The dermal collar is well developed on both the ventral and dorsal surfaces of the genital cone. The genital appendages consist of two large plates arising separately, diverging

from the middle line, and each terminating in two finger-like processes, the inner of which is the larger. The finger-like processes are bifid at their tips (fig. 4).



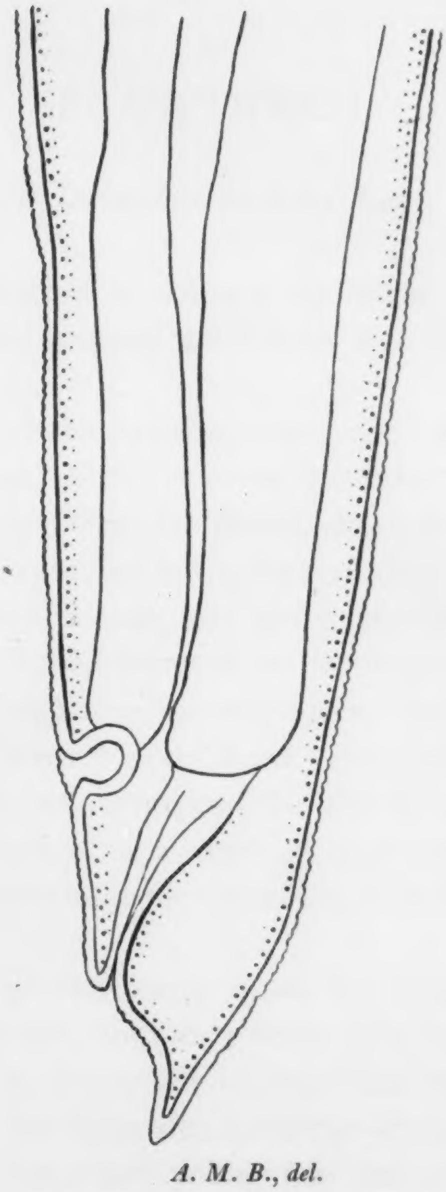
A. M. B., del.

FIG. 4. *Cylicostomum triramosum*, sp. n.

Genital cone, ventral view. × 360.

POSTERIOR EXTREMITY OF THE FEMALE. The end of the body is straight. The tail is short and conical (fig. 5). The distance between the anus and the vulva was 264μ, and the distance measured straight along the middle line of the tail from the tip to a line drawn horizontally through the anus was 168μ.

DIAGNOSIS. This worm resembles *Cylicostomum radiatum*, Looss, most closely, but may be distinguished from it by the prominence of the lateral papillae of the mouth collar, by the posterior ray of the bursa bearing three branches, and by the characteristics of the genital appendages of the male.



A. M. B., del.

FIG. 5 *Cylicostomum triramosum*, sp. n.
Posterior extremity of female, lateral view. × 90.

FISH AND MOSQUITO LARVAE IN BENGAL, BIHAR AND ORISSA, INDIA

BY

T. SOUTHWELL

(*Received for publication* 21 *June*, 1920)

Most people interested in malaria are aware of the fact that in India, and elsewhere, certain species of fish feed extensively on mosquito larvae.

We have much to learn yet concerning the habits of many of the above species of fish, their relation to other species, and the conditions under which they act effectively, before one can assess, approximately, their value as mosquito-reducing agents. In India, at least, it is only within the last ten years that the subject has received attention. The present paper summarises, roughly, information obtained through the investigations carried out by Sewell, Chaudhuri, Alcock, Bentley and Lloyd. In addition, it affords the writer an opportunity of recording, for the first time, impressions and conclusions arrived at as a result of eight years' work in India as Director of Fisheries to the Governments of Bengal and Bihar and Orissa.

Monsoon. During the early part of June, the south-west monsoon-rains commence, and, in a short time the province is more or less flooded. It is important to note that the breeding season for many species of fish coincides with the advent of the monsoon. Consequently fishes' eggs and young fish are, at this time, caught in large numbers and are found in almost every ditch and pool of water. By the middle of August, the rains are practically over and the dry season commences, continuing to the following June. The flooded areas contract, and eventually become dry; the young fish so lavishly distributed in nature become isolated in little pools and are either caught or die, except those which are successful in reaching a tank, beel or river.

Water areas. (1) *Rivers and irrigation canals.* Bengal is a low-lying country, rich in waterways. The main river, the Ganges, with its numerous tributaries, drains the province and, a little to the South of Calcutta, breaks up into the Gangetic Delta. The latter area, which is known as the Sunderbans, comprises an immense number of swift-flowing tidal streams, intersecting each other in all directions, together with swamps and dense virgin jungle. Irrigation is carried on throughout the province by means of a system of canals which arise from both sides of anicuts, or weirs, thrown across rivers. They distribute water, during the dry season, to the paddy or rice fields.

(2) *Beels.* Beels are also numerous; these are large *natural* depressions, full of water, corresponding to our lakes, for the most part retaining a connection with a river, either throughout the year or during the rains only. They, too, contain fish in considerable abundance.

(3) *Borrow pits.* Borrow pits occur plentifully. They measure two or three yards long, two or three feet wide and a foot or so deep, and are formed as a result of earth having been removed in order to elevate surrounding land, usually railway embankments.

(4) *Tanks.* Tanks (or ponds) in Bengal play a very important and extensive rôle in the economy of village life; they are utilised by the villagers for bathing, washing and for a variety of other purposes. They are exceedingly numerous. They were dug originally either because earth was necessary to elevate the ground on which a house was to be built, above the flood level, or from religious motives. In years gone by, tanks were kept in much better repair than is the case nowadays, owing, probably, to the fact that the growth and development of western education and commerce has attracted village life to the cities and towns.

Many tanks have become more or less silted up, foul, or choked with weed. The result is that they form admirable breeding-places for certain species of mosquitoes.

A considerable number of species of fish occur in tanks. The large and edible species include carps like *Labeo rohita*, and catfishes such as *Wallago attu*, *Macrones* spp., etc., but other smaller species growing to two or three inches in length are numerous. In most tanks there are found, as a rule, only a very few large fishes,

such as carps or cat-fishes, the former being individuals which have escaped the ravages of predatory species. Such small species as do occur are found, as a rule, towards the edges of the pool. The tanks in which predatory fish do *not* occur form a very small percentage. These facts are of importance in that any scheme for stocking tanks, beels, streams, etc., with mosquito larvae-eating fish which takes no account of the presence of predatory species, is doomed to failure.

Mosquito larvae-eating fish. There exists in Barbadoes a fish known as 'Millions' (*Poecilia poeciloides*, De Filippe, = *Girardinus poeciloides*), which is well known as being very destructive to mosquito larvae. It was introduced into Ceylon for that purpose about twenty years ago. It has since practically died out in the Island. It was also introduced into India by the Government of the United Provinces a little later, and a number of specimens were sent to the tanks in the Zoological Gardens in Calcutta. Apparently they did not thrive and increase. It is certain, however, that in Bengal there is at least one species (*Haplochilus panchax*, Hamilton Buchanan = *Panchax panchax*, Tate Regan) which is superior to 'Millions' as a destroyer of mosquito larvae. The species of fish best adapted for destroying mosquito larvae should breed in confined areas, otherwise they will die unless replenished year by year.

The following species of fishes occur abundantly in fresh water in India, and all are known to eat mosquito larvae extensively under natural conditions:—

Genus *Haplochilus*.

Species of the genus *Haplochilus* are small, and the adult seldom grows to three inches in length. This genus belongs to the group *Carnivorae* of the family *Cyprinodontidae* and to the sub-order *Haplomi*.

There are three species:—

1. *Haplochilus panchax* (Hamilton Buchanan). Occurs all over India. It has a flat head and lives on the surface of the water.

2. *Haplochilus melastigma* (McClell). Smaller than *panchax*. Widely distributed throughout India.

3. *Haplochilus lineolatus* (Cuv. and Val.). Grows to four inches and occurs plentifully.

All the above three species are hardy, and breed freely in confined water. Mosquito larvae are to be found normally on the surface of the water, and these fishes, which also live on the surface, devour them in nature with exceptional avidity.

Species of less importance are:—

Ambassis nama (Ham. Buch.). Two to three inches long; breeds freely in confined water, occurs abundantly.

A. ranga is smaller than the above, but similar in its habits. They are not surface feeders.

Trichogaster fasciatus (Bl. Schn.). Grows to four or five inches in length and occurs in fresh and brackish water. It has a wide distribution in India.

Badis badis (Ham. Buch.). Lives in mud and is very voracious. Occurs both in fresh and brackish water. Grows to four or five inches in length.

Barbus phutunio (Ham. Buch.). One to two inches long, and breeds in tanks. Of this genus there are at least three other species of some use as mosquito larvae destroyers, viz., *B. ticto*, *B. stigma* and *B. terio*. Some of the species have, however, a restricted distribution.

Anabas scandens (Daldorf). This species is known as the climbing perch. It possesses a respiratory system other than gills. It is able to climb small trees, and can live for a very long time entirely out of water. During the dry season, when tanks and other water areas dry up, this species buries itself in the damp mud and is actually dug up with a spade by the villagers. I have seen it taken from a depth of two feet from the surface of a dried-up pond. It grows to about eight inches in length and breeds freely in beels and even in brackish water; but it is doubtful whether it breeds in tanks, although, during the rains, its eggs and young find their way into tanks in large numbers like those of other species of fish.

Certain species of cat-fish (*e.g.*, *Wallago attu*) found in tanks also have this habit of burying themselves in the mud during the dry weather, and the impossibility of removing them from tanks—especially if they breed there—will be obvious.

There are other species (such as *Perilampus* spp., *Danio rerio*, *Barilius* spp., *Rasbora daniconius*, etc.) which are also known to feed on mosquito larvae occasionally, and it is probable that still

other species will be discovered when investigations have been extended.

We may now consider briefly the question of the reduction of mosquitoes in nature on a large scale. At the present time the stocking of tanks with fish which devour mosquito larvae is frequently advocated as a means of mosquito reduction, and it is certain that the efficiency of this method is not doubted by many. It is true that the process may be considered a slow one, but in India time has but little value.

In connection with the problem, there are a few points which call for special consideration.

It is impossible to keep tanks, beels and other waterways stocked with mosquito larvae-eating fish, owing to the fact that they are themselves devoured by other and larger predatory fish. In order to remove the large predatory species it would be necessary to pump the water areas dry, to allow them to remain dry in the sun for months, and even then one could not be certain that the species buried in the mud might not spring to life again with the first rains. Further, it would be necessary to prevent the entrance of fresh broods of predatory fish during the next rains. Now such extensive preventive measures are, to my mind, clearly beyond the range of possibility. There is the expense, the enormous number of water areas to be dealt with, and the entire absence of any organisation to undertake the work. It will be obvious, I think, that the small species of fish which normally devour mosquito larvae have only a very limited usefulness in nature, and that this sphere of usefulness cannot be extended materially; as a result, the actual reduction of mosquitoes through the agency of fish is not at present a practical scheme. It is, however, impossible to say to what degree these fishes are useful, but as these agencies have been at work for some thousands of years, we may safely conclude that the effect is negligible.

In Bengal, tanks are naturally stocked with fish during every monsoon, and they, therefore, contain the maximum quantity of fish they are able to support. The artificial introduction of large numbers of mosquito larvae-eating fish upsets the established balance, which is ultimately righted by the death of those unable

to procure sustenance or which succumb to the predatory habits of other species in the tank.

The cultivation of carp along with mosquito larvae-eating fish is sound, because carp are not predatory, and there can be no doubt but that some slight improvement would result if more care was taken to stop the careless and ceaseless introduction of predatory species into tanks. This could be effected by stocking tanks with pure fry only, instead of with mixed species.

Lastly, attention may be called to the suggestion made of attacking the problem in India in a different way. It is known that if a little oil is placed in a pond it spreads and forms a delicate film on the surface of the water. This prevents mosquito larvae from obtaining sufficient air, and thus tends to kill them. As, however, it also tends to kill small fishes, and renders the water objectionable for domestic purposes, this procedure is not considered desirable by the village population.

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OBSERVATIONS ON THE CERATOPOGONINE MIDGES OF THE GOLD COAST WITH DESCRIPTIONS OF NEW SPECIES

PART I.

BY

HENRY F. CARTER

A. INGRAM

AND

J. W. S. MACFIE

(*Received for publication* 15 *August*, 1920)

PLATES IV, V, VI

INTRODUCTORY

Small biting midges, colloquially referred to as "sand-flies," are abundant in the Gold Coast, and in many parts of the country are a vexatious pest. Very little appears to be known about them, however, only a few species have hitherto been described, and few, if any, observations have been made on their early stages and their breeding-places in this part of West Africa.

In December, 1919, a study of these midges was begun by two of us (J. W. S. M. and A. I.) at Accra. It was soon apparent that a large number and a great variety of specimens could be obtained, and that they would include a number of new species. The investigation is still in progress, but we propose to give in this and three or four succeeding papers an account—mainly descriptive—of the species, particularly those referable to the genera *Culicoides*, *Dasyhelea*, and *Forcipomyia*, obtained from December, 1919, to the beginning of May, 1920.

Most of the specimens were collected actually at Accra. Some, however, were procured in neighbouring towns and villages, and as the names of these places will have to be mentioned repeatedly in connection with the habitats of various species, it will be convenient here to explain where they are situated. The following are the places from which specimens were obtained :—

Accra : the capital of the Gold Coast Colony, a town situated on the sea-coast in a somewhat arid locality.

Oblogo : a village a few miles to the west of Accra, situated on the river Densu.

Odorkor : a small village between Accra and Oblogo.

Dodowah : a town about twenty-five miles north-east of Accra.

Adawso : a town about thirty miles north of Accra.

Nsawam : a town about twenty-five miles north of Accra, on the edge of the thick forest zone, and situated on the river Densu.

Koforidua : a town about fifty miles north of Accra.

Tafo : a town a little to the north-west of Koforidua.

Winnebah : a town on the coast a little to the west of Accra.

We have pleasure in acknowledging our indebtedness to Dr. F. H. Storey and Dr. D. Duff for specimens from the Koforidua district and Winnebah respectively, and to Dr. P. S. Selwyn-Clarke for making it possible for us to visit, in search of material, a number of the localities in the neighbourhood of Accra.

COLLECTION

ADULTS. A few specimens were taken in bungalows at night, either on the wall in the vicinity of a lamp or on the hand when writing. We also received from Dr. Storey several large collections of *Culicoides grahami*, Aust., taken in the act of biting, at Koforidua and at villages in the neighbourhood of that town. The majority of the adults collected were, however, obtained in the Accra laboratory.

It was our custom to collect small diptera in the laboratory every evening between the hours of 5-30 and 6-30, that is, during the

brief tropical twilight. They were secured in the following manner. At 5 p.m. the windows of the laboratory were closed. About half an hour later, midges began to appear on the inside of the window-panes and were collected until nightfall by placing a small tube containing potassium cyanide or wool sprinkled with chloroform over them as they rested on the glass, closing the tube by inserting a visiting card between it and the window-pane, and then lifting it away with the card still in position. If the windows of the laboratory happened to be closed during the day-time a few midges were occasionally seen on them, but it was not until nightfall that any considerable number appeared. So far as could be judged, they were endeavouring to escape, for they could sometimes be seen flying towards the light, and it is probable that they had taken refuge in the building during the day-time or in the early hours of the morning.

The collections thus made contained a large number of interesting forms and many different kinds of flies, amongst them numerous examples of *Phlebotomus*, *Culicoides* and *Forcipomyia*, both males and females. Specimens of *Culicoides* could be recognised with fair accuracy on the window-panes by their small size, dark-grey colour, and somewhat humped-back appearance. They seemed to have but a feeble foothold on the glass, and, unlike *Phlebotomus*, did not jump about from place to place but remained stationary, generally near to the wooden framework of the window, or crawled slowly along the glass. The males, by reason of their plumose antennae, were slightly more conspicuous than the females.

In these evening hunts for insects we were frequently joined by predaceous insects and small lizards. The lizards were not observed to attack midges, but on one occasion a small Empid pounced upon and carried off a specimen of *Culicoides* that we were endeavouring to capture. The same insect, which, through the courtesy of the Imperial Bureau of Entomology, has been identified as a species of *Elaphropeza* by Mr. J. E. Collin, preyed also upon *Forcipomyia ingrami*, Cart., and other, at present unidentified, species of this genus. Specimens of *Phlebotomus* (probably *P. minutus* var. *africanus*) were repeatedly seen, engorged with blood, on the heads, limbs and bodies of the lizards; they were most tenacious of their hold, refusing to let go even when the lizards were moving actively.

The lizards appeared to be quite indifferent to the attacks of these insects.

During the five months of the investigation with which we are at present concerned, over a thousand specimens of *Culicoides*, *Forcipomyia*, etc., were collected in this way, including representatives of at least twenty different species. This is of considerable interest in view of the fact that midges are not especially troublesome at Accra. A number of the specimens on examination appeared to be engorged with blood. It is noteworthy that we were never consciously bitten by any insects other than mosquitoes whilst making these collections in the laboratory, but it should perhaps be mentioned, although it may have no significance, that the one of us who made most of the collections suffered from nine separate short attacks (one to seven days) of fever during the period, and that on none of these occasions were malaria parasites found in his blood.

LARVAE AND PUPAE. Larvae and pupae were obtained by collecting samples of the water, mud, or vegetable matter from small pools, rot-holes in trees, old canoes, crab-holes, the rotting roots of banana plants, etc. The pupae of aquatic forms, such as *Culicoides*, could sometimes be seen floating on the surface of the water at the edge of pools, in dug-out canoes, etc., and could be collected by means of a dipper; occasionally larvae also could be seen, but their small size and their habit of burying themselves when disturbed made this a very difficult matter. As a rule, it was not possible to determine in the field if larvae and pupae were present, therefore we soon adopted the plan of collecting samples of any materials we thought likely to harbour the insects and transporting them to the laboratory for examination at leisure. In this way a large number of samples was examined from a great variety of situations.

The materials from which we obtained larvae and pupae may be considered, so far as the methods of collection are concerned, as belonging to one of two types: samples of moist débris, and fluid samples.

The samples of moist débris included such materials as the mud from the edges of pools, the vegetable matter collected at the bottom of rot-holes in trees, the rotten wood of canoes, and the decomposing matter from the bases of banana plants. Such materials were

carried to the laboratory in cigarette tins or small jars, and were then turned out into larger glass jars and covered by glass plates. Water was added to these samples in such a way that only about one-half of the material was submerged, so that the conditions might be suitable for both aquatic and terrestrial species.

The fluid samples, which were obtained from pools and puddles, rivers, crab-holes, bamboo-stumps, rot-holes in trees, etc., included some of the mud or other débris forming the natural bottom, and were usually collected in glass jars which only required to be securely covered on their arrival at the laboratory. If, however, they had to be transported a long distance by train, motor car, or bicycle, involving continual joltings, we found it preferable to drain off most of the water by pouring the sample on to a pad of filter paper or vegetable matter contained in a tin, the bottom of which had been pierced in one or two places. In this connexion it may be mentioned that a sample of the contents of a rot-hole in a tree containing mosquito larvae, which was sent to us through the post by a modification of Legendre's (1916) method of transportation, which we have found of considerable value, was found on arrival to contain also living larvae of *Culicoides*.

All the samples collected were kept at least a week before being discarded. This was done because a day or two often elapsed before larvae were discovered in them, and in order that any buried pupae present might have a chance of hatching.

SEGREGATION

From many samples there emerged several different species of midges. The small size of these insects, and the frequent slight specific variation in the larvae and pupae generally rendered them indistinguishable in life, and, therefore, it was necessary, in order correctly to correlate the immature and adult stages of a species, to obtain the larval and the pupal pelts of single individuals. The neglect of this precaution would inevitably result in incorrect associations.

For this purpose we isolated single larvae or pupae in small glass tubes, and in several cases succeeded in rearing the adults

and in recovering the pelts. It will be readily understood, however, that this was not easy, and that in many cases we were unsuccessful. In order to be able to find such a minute object as the crumpled and collapsed larval pelt, it was necessary to reduce the amount of the medium to a minimum, so that there was danger of starving the larva or rendering the conditions otherwise unsuitable for its existence. It was also necessary, of course, to examine very carefully the débris placed in the tubes to see that it contained no other small larvae, old pelts, or predaceous insects. In the case of *Culicoides*, the larvae and pupae of which are aquatic and transform at the surface, the pelts were comparatively easy to find, as they generally remained floating; in the case of *Dasyhelea* it was more difficult, as they were left embedded in the solid medium and had to be sought by teasing out the materials under a dissecting microscope.

EXAMINATION

ADULTS. These small insects shrink greatly and unequally during the process of drying, so that morphological characters are obscured and little reliance can be placed on measurements. Such specimens, however, are all that are usually available. The individual variations in size are moreover considerable, and any measurements that can be given are therefore only approximate. The most reliable and satisfactory measurements, because they are least subject to the effects of shrinkage, are those of the wing; in freshly killed midges the ratio of the length of the wing to the length of the body, excluding the head, was found to be approximately as 1 is to 1·2.

Those measurements which we have selected, the length of the body and the length and breadth of the wing, are, unless otherwise indicated, made from mounted specimens. We have recorded the length of the body from the anterior margin of the thorax to the posterior end of the abdomen. The head is excluded, because one of the most pronounced and variable effects of drying is the retraction of the head under the thorax: in some specimens it is almost completely hidden, in others it is only slightly retracted. Measurements of specimens after immersion in pure carbolic acid are very

close to those of the living insect. This medium has the effect of clearing and distending the dried midges, and if used carefully does not over-distend them. It is, therefore, a most convenient fluid in which to mount specimens for the examination of morphological characters.

Another effect of drying is to obliterate delicate markings and to obscure shades of colouring. Dried midges are with few exceptions brown; in life they are more often a dark olive-green colour. Here again, however, we have thought it best to describe the conditions seen in dried specimens, contenting ourselves with a brief reference to the appearances in fresh specimens only when the differences were notable. It should be understood, however, that in the living insect the markings are almost invariably brighter and clearer, and that many a thorax or abdomen, which in dried materials appears uniformly brown, may have been originally beautifully but delicately patterned.

The drawings of the wings were made from dried specimens. After immersion in pure carbolic acid, or when mounted in balsam, the pale markings appear to be larger and more diffuse. In examining the thoracic ornamentation or the wing markings, it is necessary to have unshrunken specimens and to view them from all points in order to obtain the effect of light falling on them at different angles. It is possible to form an entirely erroneous conception of the pattern if only shruken specimens are available, or if they are viewed with light falling on them from one direction only. With a hand lens (× 16) or a low power of a binocular microscope the patterns are appreciated best; under higher powers, such as those of an ordinary microscope, the patterns tend to break down. A low power of a binocular microscope was used for the descriptive work in the succeeding papers.

It may be mentioned here that, apart from antennal and genital characters, there are not great differences between the sexes in these midges. The male in most respects is similar to the female, but smaller, and of slighter build. In general the dark markings in the male tend to be more diffuse and conspicuous than in the female.

PUPAE. The best materials for examination are specimens which have recently pupated or pelts. The pupal case is sufficiently

rigid to retain its form after the emergence of the adult insect. Such cases are more suitable for study than the pupae themselves, as the armature of spines and tubercles is not obscured by the hairs and organs of the enclosed insect. In older pupae the enclosed insect can be seen clearly, and after treatment with clove oil, pure carbolic acid, etc., can be examined in detail. The most convenient medium for the examination of the external structure is pure carbolic acid in which, when mounted on a hollow slide, the pupa or its pelt can be rolled from side to side and viewed from every aspect.

LARVAE. The larvae should be fixed by dropping them into hot fluid (alcohol, formalin, or water) so as to prevent undue shrinkage and the retraction of the anal gills. For examination pure carbolic acid is again a very convenient medium; it clears the head thoroughly but renders the body rather too transparent. This drawback, however, can be easily corrected by diluting the medium with alcohol.

Larval pelts are not very suitable for detailed examination, owing to the fact that the body segments are more or less telescoped and the head is split on each side dorsally.

THE VALUE OF PURE CARBOLIC ACID IN THE STUDY OF SMALL INSECTS. In the study of these small midges we have found pure carbolic acid a reagent of the highest value. Reference has already been made to the fact that in this medium the dried insects are distended so that they reassume their natural dimensions. This action is of value, not only because it enables accurate measurements to be made of the various parts, but also because the most minute structures, such as sculpturing on the antennae and sensory hairs on the palpi, can be clearly seen and examined with high powers of the microscope.

The advantages which we claim for this medium are the following:—

1. It rapidly clears specimens preserved dry, in alcohol, or in watery solutions such as formalin, without shrinkage or distortion.

2. It restores the specimens to their natural forms, and in doing so re-expands such organs as the palpi, the antennae, claspers, etc.

3. It does not denude the specimens.

4. In it, on a hollow slide, the specimens (adults, pupae, or

larvae) can be 'rolled' from side to side, thus enabling any particular object to be examined from every aspect. This is a very important advantage in studying the genitalia, the spines on the antennae, the tubercles of pupae, etc.

5. At the end of each examination the specimen can be put away in a tube of alcohol or formalin, and subsequently taken out for re-examination as often as required; or it can be permanently mounted in Canada balsam.

Except when the structures are very dark and very highly chitinised, pure carbolic is, in our opinion, preferable to caustic potash as a clearing agent. The latter reagent takes longer to act, softens the tissues so that they are unnaturally flattened even by the weight of a cover slip, and, owing to the subsequent manipulations attending washing and dehydration, is apt to denude the hairs and to distort the more delicate structures to a misleading extent.

BIONOMICS

ADULTS. The midges are phototropic. When reared in glass jars in the laboratory they are always found resting or crawling about upon the side nearest the strongest light; reversing the position of the jars causes them to change their positions. If they have been reared in a small glass tube they are easily induced to leave it and ascend into another tube by the simple expedient of inverting the one tube over the other and pointing the bottom of the upper one towards a strong light.

In the case of some species at any rate, males and females appear to hatch at different times. In one instance, from débris procured from a rotting tree, thirty-two males of a species of *Culicoides* (*C. clarkei*, sp. n.) emerged in succession before a single female appeared, then a series of a dozen females hatched, followed by two more males. Of another species (*C. eriodendroni*, sp. n.) forty females were reared but not a single male.

A newly hatched *Culicoides* is capable of walking about as soon as it leaves the pupal case, and of flying within ten minutes of its emergence. In the case of *Dasyhelea*, if the pupae have become dislodged from their natural positions in rotten wood or other

vegetable matter, and are floating in water, the adults seldom succeed in hatching completely.

As has already been said, most of our specimens were obtained in the evening on the windows of the laboratory under circumstances which suggested that they were attempting to escape from the building. At the same time, when we were collecting large numbers of specimens in the laboratory, very few were to be found in our bungalows which were not far distant, and those that were found appeared to have been attracted by lights. This difference may have been due to the fact that whereas the laboratory was closed at night our bungalows were more or less open at all times.

During the five months of this investigation midges belonging to the genera *Culicoides* and *Forcipomyia* were always more or less numerous in the laboratory in the evening. Some of the species were abundant throughout, some appeared to show a seasonal variation, and others were taken only on rare occasions. At the end of the description of each species we have recorded the months during which it was collected, and have noted any peculiarities regarding its prevalence. It may be stated here, however, that in December, 1919, when the investigation was started, midges were fairly common, and some six species of *Culicoides* and three of *Forcipomyia* were secured. Throughout January all but one of the same species were taken in larger numbers, and in addition several new species were collected. The total number of specimens captured in January was the largest of any month during the period under consideration, fifteen or twenty specimens of *Culicoides* alone being taken each evening, and on one particular occasion no less than seventy. In February, the height of the dry season, much the same species were collected, but in greatly reduced numbers; indeed several may be said to have practically disappeared, as only single specimens were obtained. In March the commoner species again increased, and several new species were secured, so that in this month the largest number of different species was collected. In April collection was carried out less systematically, and this may have accounted for the fact that certain of the rarer species were not taken, although all the commoner ones were abundant. In January, therefore, the largest number of specimens was collected; in March the greatest number of different species. *Forcipomyia ingrami* was

the commonest species of midge upon the laboratory windows during the period, a fact that is readily explained since it was being artificially reared at the time; next to it in frequency of occurrence was *C. schultzei* (End.). It may be mentioned, although it does not properly concern us here, that during May and June, with the onset of the rainy season, the number of *Culicoides* fell off greatly and the number of *Forcipomyia* increased.

EGGS. Except in the case of *F. ingrami*, no attempts were made to obtain oviposition with any of the midges captured. On one occasion, however, a female of *F. castanea*, Wlk., was found which had a few eggs attached to the extremity of the abdomen. These were dark, elongate oval, somewhat pointed at the ends and surrounded with what appeared to be a delicate gelatinous capsule; the average measurements of these were, length 240μ, greatest breadth 80μ. The abdomens of several captured females of various species of *Culicoides* and *Dasyhelea* were seen, on examination in carbolic, to be filled with eggs. These, in both genera, are relatively large and appear to be very long and narrow and slightly curved with bluntly rounded ends (sausage-shaped); the average dimensions of three such eggs of *C. grahami*, Aust., were, length 303μ, greatest breadth 45μ.

LARVAE AND PUPAE. It will be convenient to record the few bionomical observations we have made on species belonging to the genera *Culicoides* and *Dasyhelea* separately, as these are the only genera of which we have hitherto succeeded in procuring and identifying a sufficient number in their early stages. Any observations we have made on other species will be included in the text of the systematic descriptions. A full account of the early stages of *Forcipomyia ingrami* has already been given by one of us (Carter, 1919); this midge was reared frequently in the laboratory and its larvae were found twice during this investigation in material taken from the base of a banana stump at Nsawam, and from a rot-hole in a cotton tree at Oblogo.

CULICOIDES. The only true members of this genus of which the larval and pupal stages have been described in any detail, appear to be *C. kiefferi*, Patt. (Patton, 1913) and *C. pulicaris*, L. (Goetghebuer, 1919).* We were successful in rearing nine different

* In a previous paper (1914) Goetghebuer gives an excellent account of the early stages of *Dasyhelea versicolor*, Wtz., which he places in *Culicoides*.

species of *Culicoides* from materials collected in the manner described. They were found in rot-holes in trees (Plates V and VI, figs. 4, 6 and 8), such as the flamboyant (*Poinciana regia*), the silk-cotton (*Eriodendron anfractuosum*), the cashew (*Anacardium occidentale*), the mango (*Mangifera* sp.), a species of *Cynometra*, probably *C. megalophylla*, and one or two other species not determined; in the partly decomposed and water-laden roots or bases of banana stumps (Plate V, fig. 5); in canoes tied to the banks of rivers (Plate VI, fig. 7); in a backwater of a river which was used as a washing-place; and in pools and puddles such as are frequently found in the vicinity of stand-pipes (Plate IV, figs. 2 and 3). In the systematic descriptions of species, which will be published later, notes will be given of the situations in which early stages were collected. Larvae which appeared to be those of some species of *Culicoides* were also obtained from a clump of bamboos by a river, from crab-holes at the edge of a lagoon, and from the margins of a large pool, but were not reared through to the adult stage.

With one exception, all the species of *Culicoides* reared had spotted wings. The single clear-winged species was bred from materials obtained from a rot-hole in a cotton tree and from the base of a banana plant, and it is noteworthy that this was the only *Culicoides* found in the latter situation which was, however, a favourite breeding-place of several species of *Dasyhelea*.

It is perhaps worth recording that, although twelve species of *Culicoides* were captured upon the laboratory windows between the beginning of December and the end of April, with the exception of *C. accraensis*, sp. n., of which the larvae and pupae were found floating in water accumulated in a rot-hole in a flamboyant tree close to the laboratory, the early stages of none of the others were found in any collection of water within a radius of 150 yards of the laboratory, despite diligent search for them upon many occasions.

Small samples of materials occasionally produced very large numbers of midges; they also sometimes continued to yield larvae for a long time. In one instance some material taken from a rot-hole in a flamboyant tree on the 10th December continued to produce larvae (*C. accraensis*) in gradually diminishing numbers until the 20th March.

From the samples of material collected there emerged often more than one species of midge, and from some, such as that taken from a rot-hole in a cotton tree at Nsawam, as many as six different species of *Culicoides* were reared. It was not possible in every case to isolate the larvae and pupae, but we were fortunate enough to procure the larvae of five and the pupae of seven species.

The larvae are slender, eel-like creatures, about 3 mm. long. All those that we collected were somewhat similar in their appearance and, so far as they were observed, in their habits also; but the species for which we propose the name *C. accraensis* was the one we were able to procure most abundantly and to study most closely at Accra, and, therefore, the observations recorded below refer particularly to it—points of difference with regard to other species only being noted.

The colour of the body of the larvae is dull white, and it usually remains unaltered until pupation; the head is yellowish-brown. In the cases, however, of three larvae which came under our observation, two collected from a crab-hole at Christiansborg, a suburb of Accra, and one from a bamboo at Oblogo, the colour gradually darkened to a mahogany brown. These larvae, unfortunately, died, and it is not known to what species they belonged, or whether indeed the dark colour may not have been due to some pathological condition.

The larvae normally develop in water, but appear to be capable of surviving for a time in moist situations where no free water is present. That they can survive for at least six days without actual immersion in water is indicated by the two following experiments.

1. A large sample of débris scraped from a rot-hole in a flamboyant tree was divided into two equal portions and each portion placed in a glass jar and covered. To one portion water was added, so that the solid matter was almost completely submerged: *Culicoides* larvae (*C. accraensis*) were observed in this jar the next day, pupae on the fifth day, and adult insects on the ninth day. The other portion was not treated in any way: no larvae, pupae, or adult midges were seen in this jar during an observation period of ten days.

2. Débris scraped from a rot-hole in another flamboyant tree was similarly divided into two equal portions. To one portion

water was added: larvae of *C. accraensis* were seen in this jar two days later. The other portion was left untouched; six days later, as nothing had appeared in this jar, water was added, and two days after this well-grown larvae of *C. accraensis* were observed.

The movements of the larvae in water are active, and are effected by means of a vibratile motion of the whole body, which has been compared with that of a spirochaete (Patton, 1913). The movements are intermittent. Notwithstanding these convulsive movements, progression, especially when descending from the surface is not very rapid, and is slower than that of a mosquito larva of the same size.

If when swimming at the surface the larvae are disturbed, they work their way downward and burrow, head first and with extraordinary rapidity, into the débris at the bottom and disappear from view completely. If the jar be then left undisturbed for an hour or so they reappear, but do not always leave the débris entirely. They seem, indeed, to spend the greater part of their existence buried in the fine mud at the bottom with only their heads and the first three or four body-segments projecting, an attitude in which they resemble tiny protruding roots of plants. When thus situated, any movement, or even the slightest vibration, causes them immediately to retract completely.

Larvae buried in the débris at the bottom of a vessel may frequently be induced to come to the surface by replacing the supernatant water by fresh water. The larvae appear to be susceptible to light. If kept in rectangular glass jars they will usually be found, when at the surface, at that side or angle of the jar directed towards the strongest light. In this respect they behave in a manner similar to the larvae and pupae of certain mosquitoes, such as *Stegomyia fasciata*, Fabr.

The larvae appear to survive transportation well, and may be carried either in the natural watery medium, in moist débris, or stranded on moss or filter-paper. On one occasion a sample containing larvae of *Culicoides* was received safely through the post.

The duration of the larval stage was not determined in any of our species, but it is probably largely influenced by the food supply, and may certainly extend over several weeks.

When about to pupate the larvae frequent the surface, usually

hugging the side of the jar next to the light. They often may be seen twining themselves into loops and S-shaped curves about small floating particles. It is possible that these raft-particles assist in the separation of the pupae from the larval pelts, because the latter are often found attached to them; but this fact may be due to surface tension, and pupation can occur quite readily in the absence of any such floating particles. At this stage the three anterior segments of the body are much enlarged and the eyes are situated far back in the head.

Pupation takes place at the surface. The pupa emerges through the anterior part of the body of the larva, leaving a pelt in which little can be distinguished but the head and the long hairs at the posterior end of the last body segment. The larval pelt may often be found floating beside the pupa, from which, however, it is entirely separated. It is a very small object, and is not suitable for detailed study because the abdominal segments are telescoped and the posterior parts of the head is split on each side of the median dorsal plate (clypeus), from its posterior margin to a point a little behind the anterior end.

A detailed description of the pupae will be given later. Those of males are smaller than those of females. When newly emerged from the larval skin the pupae are almost white but speedily change to a golden-brown colour which darkens before the adult insects emerge, becoming in some species almost black.

The pupae are aquatic, and float in a vertical position with the body extended and the trumpets in contact with the surface. They are sluggish and exhibit only slight translatory movements; they are, however, more active than the pupae of *Forcipomyia ingrami*, and if stranded on the sides of a glass vessel by tilting, are quite capable of wriggling back to the water over a distance of at least one inch. Such movements as they do exert are effected by antero-posterior and lateral motions of the abdomen. None of the pupae observed by us employed the processes at the posterior end of the abdomen as hooks to anchor themselves as, according to Patton (1913), do those of *C. kiefferi.*

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water. They will live, however, and the adult insects will hatch from them readily enough if they are stranded upon a solid surface, provided that they are kept moist and are laid upon their ventral surface so that air can enter their respiratory trumpets.

The duration of the pupal stage is from three to five days. Warning is given of the approaching emergence of the adults by an apparent darkening of the pupae, the change of colour being due to the darkening of the enclosed insect. When the adult insect emerges, the pupal case splits down the middle of the dorsum of the cephalo-thorax from the level of the bases of the respiratory trumpets to a point a little in front of the posterior margin; the antero-median portion of the cephalo-thorax is also split on its lateral and posterior sides and raised like a lid or operculum. After the escape of the adult insect, the pupal pelt retains its shape, and remains, full of air, floating on the surface. It is very suitable for examination on account of its translucency and because the parts are but little distorted.

DASYHELEA. We were successful in rearing ten different species of *Dasyhelea* from materials collected, in the manner described, from rot-holes in trees, such as the flamboyant, the silk-cotton, the mango, a species of *Cynometra* probably *C. megalophylla*, and another tree not specifically identified, from the partly decomposed roots or bases of banana stumps, and from the rotted wood at the sides and ends of canoes (c.f. Plates V and VI). The majority of the specimens of *Dasyhelea* obtained were, indeed, reared in this way, only a few being collected on the windows in the laboratory or on the walls in a bungalow at Accra.

As in the case of *Culicoides*, there often hatched from small samples of materials large numbers of specimens belonging to several different species. For example, from one portion of rotted banana fibre, which weighed about a pound and a half, more than a hundred specimens emerged in the course of the five weeks it was kept under observation. Five different species of *Dasyhelea* were obtained from this small sample.

Owing to the occurrence of more than one species in many samples, and because at first we did not know the conditions necessary for the rearing of isolated individuals, we were unable to secure the early stages of all the species bred. We did, however,

succeed in procuring the larvae of four or five and the pupae of seven species.

The larvae are similar in appearance to those of *Culicoides*, and have yellowish-brown heads and creamy-white bodies. The cuticle covering the body is very thin and almost transparent, so that the internal organs can be seen through it. When living in dark coloured débris the larvae may, therefore, appear to be brownish, owing to the presence of ingested matter in the intestine.

The larvae live buried in moist fibrous débris, such as rotten wood or the decaying stumps of banana plants. They were never seen on the surface of such materials, but were discovered only by teasing out with needles small portions of the samples. When isolated in small tubes containing a little moist fibrous matter the larvae rapidly buried themselves and were not again seen at the surface.

Although requiring moisture for their development, the larvae are not truly aquatic, and are unable to survive submersion in water. Their natural habitat appears to be the interstices between the fibres of vegetable matter, preferably when rotting, where there is a certain amount of moisture. If the materials in which they are living are flooded with water the larvae die, but if only sufficient water is added to keep the mass moist they thrive well in glass jars, pupate, and subsequently attain the adult form.

The movements of the larvae are relatively sluggish. When placed in water they do not swim with active vibratile movements in the manner of the larvae of *Culicoides*, but crawl about laboriously at the bottom. They crawl rather more actively over solid materials such as banana fibre, and rapidly bury themselves in them, and they are capable of climbing up the sides of a glass jar for a distance of a few inches. The manner of ascent is either a slow crawling or by a bending of the body laterally into a loop, so that the posterior end is brought close to the head, followed by a straightening of the body which forces the head end upward.

The larvae survive transportation well and may be carried in their natural medium, provided that it is not completely water-logged, in jars or tins, or any other convenient receptacle. The duration of the larval stage was not determined in any of the species we collected, but it appeared to be long (several weeks) in some

cases, and is probably largely dependent on the food supply and the temperature.

Owing to the fact that the larvae live buried out of sight in moist fibrous materials, their behaviour under natural conditions could not be observed. When about to pupate, however, they appear to come close to the surface. The larval pelt may often be found lying close to the posterior end of the pupa, but separated from it. It is a very small and inconspicuous object, because the body segments are telescoped. The pupa appears to emerge from the larval skin in the same manner as in *Culicoides*.

The pupae resemble those of *Culicoides*, but may sometimes be distinguished by the shape of the respiratory trumpets. A detailed description of the morphological characters will be given later. They are not truly aquatic, and are not naturally found floating in water. Pupation takes place close to the surface of the material in which the larvae develop; the pupae remain embedded in it with their bodies outstretched, the respiratory trumpets and the dorsal portion of the cephalo-thorax only protruding. They are, therefore, invisible to the naked eye, and even after the adult insects have emerged the pelts are difficult to find, because they remain partially embedded in the fibrous matter.

The pupae of *Dasyhelea*, if removed from their natural positions and laid on damp filter-paper, are more inert than those of *Culicoides*; they make no attempt to alter their position unless they have been placed on their backs, when they try to turn over so as to bring their dorsal side uppermost. When placed in water they float at the surface in the same manner as *Culicoides* pupae, but do not long survive. A large number of pupae of two species of *Dasyhelea* were found on several occasions in water collected at the bottom of canoes tied to the bank of the river Densu at Oblogo: the majority of them were already dead or died during the week they were kept under observation, and the few adults which did emerge were found dead on the surface of the water or incompletely detached from the pupal cases. Somewhat greater success followed when the pupae were removed from the water and laid on damp filter-paper, but even then the large number of adults which failed to emerge completely suggested that the conditions were unnatural. It was found later that the rotting wood at the ends and sides of

these canoes was a favourite breeding place of several species of *Dasyhelea*, and it is probable, therefore, that the pupae found in the water in the canoes had been washed by rain from these situations.

The duration of the pupal stage is three or four days. As in the case of *Culicoides*, warning is given of the approaching emergence by an apparent darkening of the pupae. After the escape of the adult the pupal case may be found still partially embedded in the natural fibrous medium. It retains its shape, and is filled with air and floats to the surface if liberated by teasing the materials under water. When the adult insect emerges the pupal pelt is split in the same manner as that of *Culicoides*.

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EXPLANATION OF PLATE IV

Breeding-places of *Culicoides schultzei* (End.).

Fig. 1. Small pool by railway line.

Figs. 2 and 3. Puddles near stand-pipe.

Fig. 1

Fig. 2

Fig. 3

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EXPLANATION OF PLATE V

Fig. 4. Rot-hole in fork of flamboyant tree (*Poinciana regia*); breeding-place of *Culicoides accraensis*, sp. n.

Fig. 5. Stumps of banana plants; breeding-places of *Culicoides inornatipennis*, sp. n., *Dasyhelea* spp. (three species) and *Forcipomyia ingrami* (Cart.).

Fig. 6. Rot-hole in a species of *Cynometra*; breeding-place of *Culicoides accraensis*, sp. n., *C. clarkei*, sp. n., and *Dasyhelea* spp. (two species).

Fig. 6

Fig. 5

Fig. 4

EXPLANATION OF PLATE VI

Fig. 7. Partially waterlogged canoes; breeding-places of *Culicoides schultzei* (End.), *C. similis*, sp. n., and *Dasyhelea* spp. (three species).

Fig. 8. Rot-hole in the stump of a silk-cotton tree (*Eriodendron anfructuosum*); breeding-place of *Culicoides accraensis*, sp. n., *C. clarkei*, sp. n., *C. eriodendroni*, sp. n., *C. inornatipennis*, sp. n., and *C. punctithorax*, sp. n.

Fig. 7

Fig. 8

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OBSERVATIONS ON THE CERATOPOGONINE MIDGES OF THE GOLD COAST WITH DESCRIPTIONS OF NEW SPECIES

PART II.

BY

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AND

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PLATES VII AND VIII

SYSTEMATIC ACCOUNT

Since the literature relating to the classification of the *Ceratopogoninae* reveals some confusion in the conceptions of certain genera, and in view of our imperfect knowledge of the biology of these little flies, it has been considered advisable to preface some of the genera dealt with by an account of the external morphology of the adults and immature stages. These accounts are drawn up from the material contained in our collections, and conveniently summarise the characters common to all the species we have examined. The subsequent specific descriptions are thus made as brief as possible.

The types and co-types of the new species described herein have been deposited in the museum of the Liverpool School of Tropical Medicine.

Genus *CULICOIDES*, Latr.

Ceratopogon, Meig. (pro parte). Illiger's Mag. Ins. Vol. II, 1803.
Culicoides, Latr. Gen. Crust. et Ins. Vol. IV, 1809.
Haematomyidium, Goeldi. Mem. Mus. Paraense, 1905.
? ***Oecacta***, Poey. Mem. Hist. Nat. Cuba. Vol. I, 1851.

EXTERNAL MORPHOLOGY

ADULTS. *Head*. Eyes bare; in the female usually separated dorsally by a narrow, parallel-sided, strip of integument which is bounded at the vertex by an internal transverse chitinous band, immediately below which is a single strong hair; in the male usually more widely separate than in the female, with a Y-shaped chitinous thickening extending from the vertex to the middle of the frons (fig. 1). Vertex and occiput, in both sexes, with numerous,

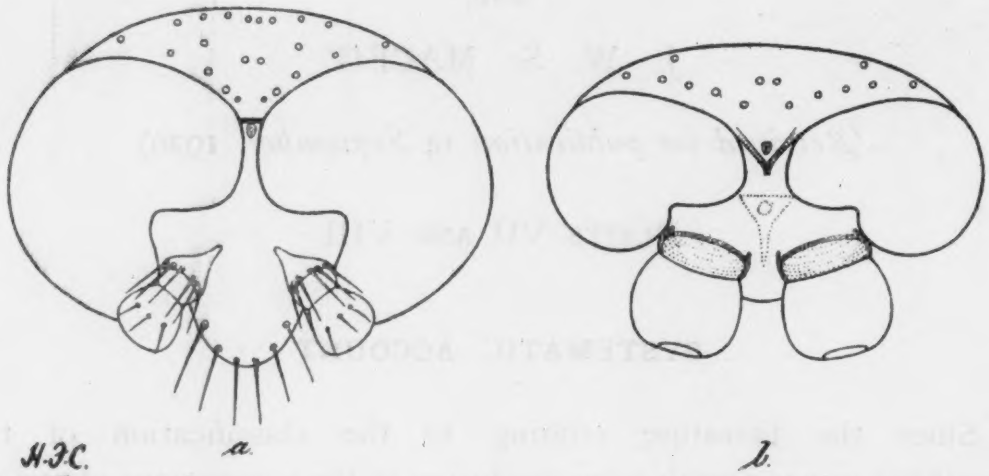

FIG. 1. *C. distinctipennis*, Aust. *a*—head of female; *b*—head of male. (× 140.)

stout, forwardly projecting hairs. Clypeus moderately pronounced, hairy.

Mouth-parts. Proboscis about as long as the head in the female, shorter in the male. The component organs of the female proboscis are shown in fig. 2. The labium is fleshy and bears a few relatively long, and several short hairs. The remaining organs are strongly chitinised and serrated distally. The labrum is armed with three terminal recurved teeth and four

teeth on each side. The broadly rounded distal margin of the hypopharynx is divided into several minute, closely apposed teeth. The mandibles and maxillae are each armed with several (fourteen to sixteen) strong teeth, those of the maxillae being relatively large and widely separated. In the male the labium is similar to that of the female but is rather narrower; the remaining organs are shorter, more delicate and less powerfully armed. The labrum, although provided with small sub-apical recurved teeth, is devoid of lateral teeth, and the extreme apex is drawn out into a membranous fringe. The hypopharynx is well-developed but is less

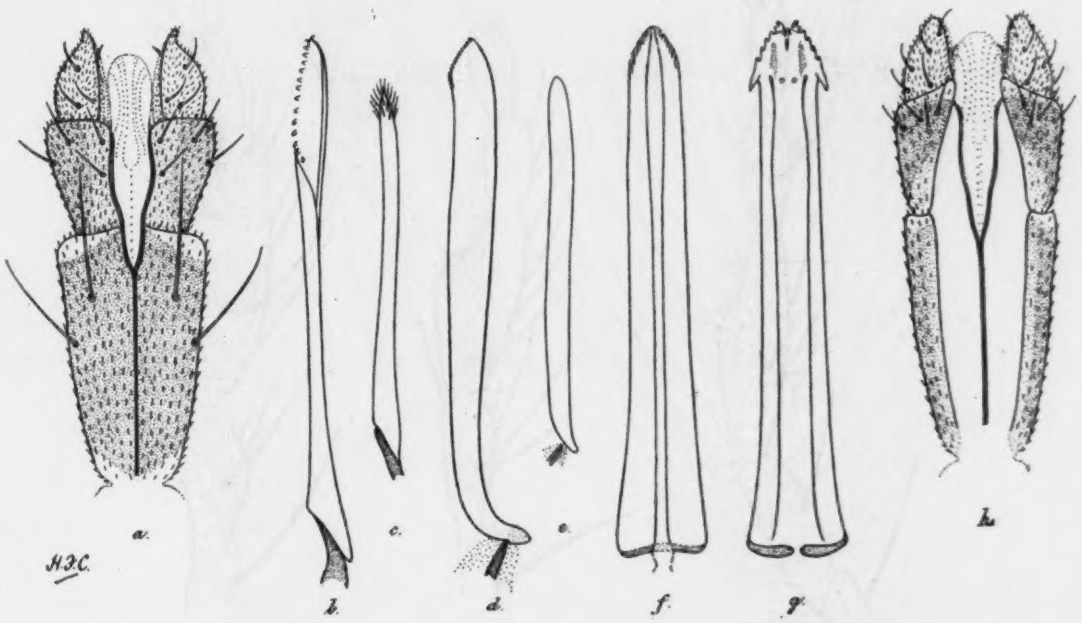

FIG. 2. Mouth-parts of *C. austeni*, sp.n. *a*—labium, ventral view (♀); *b*—maxilla (♀); *c*—maxilla (♂); *d*—mandible (♀); *e*—mandible (♂); *f*—hypopharynx ♀); *g*—labrum (♀); *h*—labium, dorsal view (♀). (All × 270 circa.)

heavily chitinised than in the female, and distally narrows to a finely rounded apex bearing two or three minute hairs. The mandibles (fig. 2 *e*) may or may not be serrated, but the teeth, when present, are reduced in size and number. In the males of *C. schultzei* (End.) and *C. distinctipennis*, Aust., each mandible bears four teeth. The maxillae (fig. 2 *c*) differ considerably from those of the female; they are rather sharply attenuated distally, and the extremity is covered with minute hairs. The palpi (fig. 3), in both sexes, are composed of five segments, bearing moderately long and short hairs, the first, fourth and fifth segments short, the second and third long, usually

sub-equal, each about twice the length of any of the other three; third segment expanded near the middle or anteriorly and containing a deep pit or sensory cup, opening on the inner aspect, in which are a number of minute modified drum-stick-like hairs. Palpi of the male smaller than those of the female.

Antennae (fig. 4). Antenna of the female composed of fifteen segments, pilose; the torus (second segment) dark brown, the flagellum (segments three to fifteen) paler brown with the last two or three segments slightly darker. All the segments are sharply

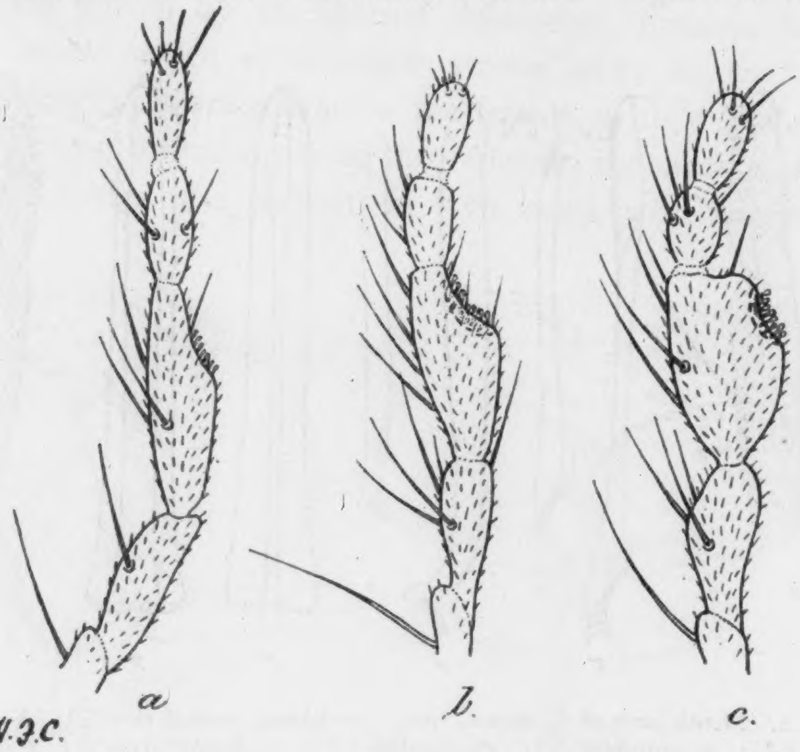

FIG. 3. Palpi of females of: *a*—*C. austeni*, sp.n.; *b*—*C. distinctipennis*, Aust.; *c*—*C. accraensis*, sp. n. (× 330.)

separated one from another. First segment small with a few relatively stout hairs arising anteriorly and reaching to about the middle of the torus; the latter sub-spherical with five or six rather short hairs arising near the anterior margin. Third segment ovoid and stalked posteriorly, larger than the fourth. Segments four to ten sub-spherical, ovoid or sub-cylindrical, becoming progressively longer towards the tenth; segments eleven to fifteen elongate, sub-cylindrical, each from three to four times as long as the greatest breadth. The terminal segment is tapering and ends in a bluntly

rounded apex. Hairs on the basal segments short, about twice the length of the segments, arranged in whorls; each segment bears a whorl of five or six hairs, and short slightly curved dorsal spines arising anteriorly. On the third segment are nine or ten hairs,

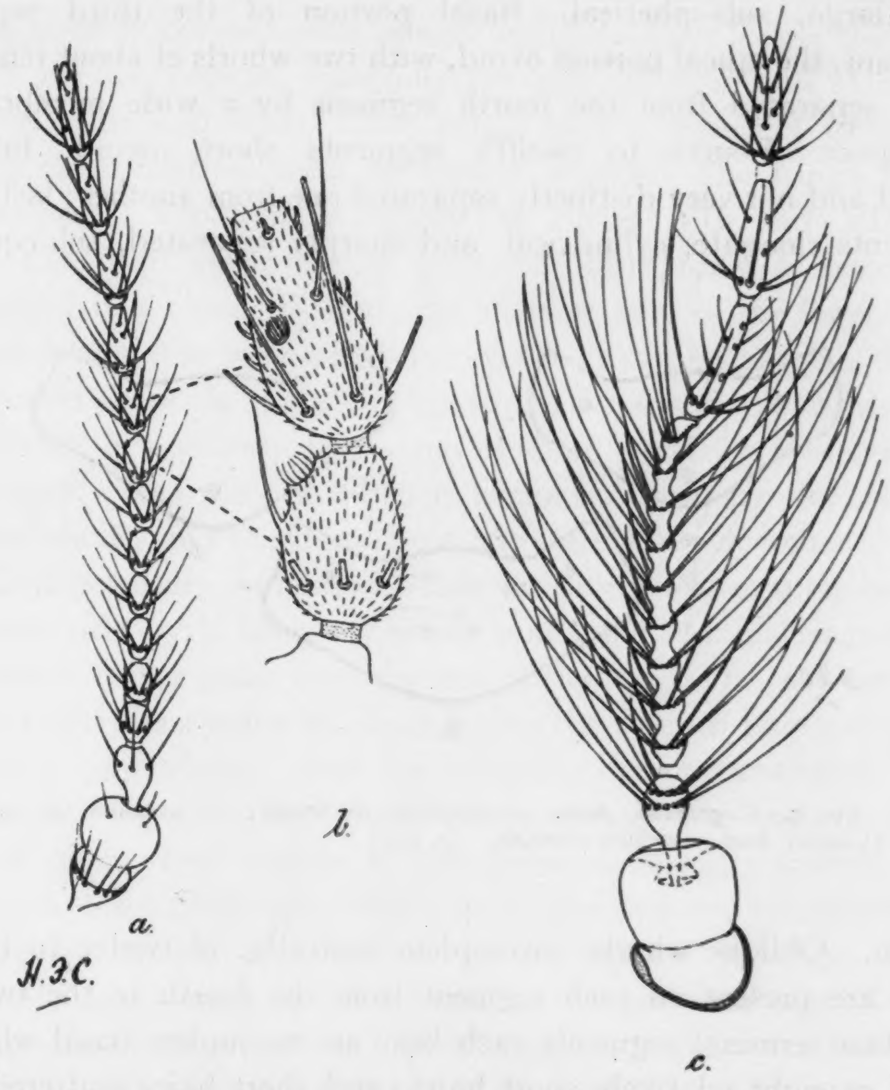

FIG. 4. *a*—*C. schultzei* (End.), antenna of female; *b*—tenth and eleventh segments more highly magnified; *c*—*C. distinctipennis*, Aust., antenna of male (comparatively few of the plume hairs are shown). (*a* and *c* × 140, *b* × 550.)

sometimes arranged in two incomplete whorls. Hairs on the five distal segments usually rather shorter than the segments, those arising posteriorly forming whorls of six to eight hairs, the rest scattered; several very small curved spines occur on each of the last five segments. Minute pits bordered with hairs are present on all

the flagellum segments; three or less are usually present on each segment, but the number and distribution varies.

Antenna of the male composed of fifteen segments, slightly longer than that of the female, plumose, the hairs adpressed and not standing out from the shaft when the insect is at rest or dead. First segment broad, chiefly membranous, without hairs. Torus very large, sub-spherical. Basal portion of the third segment elongate; the apical portion ovoid, with two whorls of about ten hairs each, separated from the fourth segment by a wide membranous interspace. Fourth to twelfth segments short, ovoid, broadly united and not very distinctly separated one from another; last three segments elongate, cylindrical, and sharply separated, sub-equal in

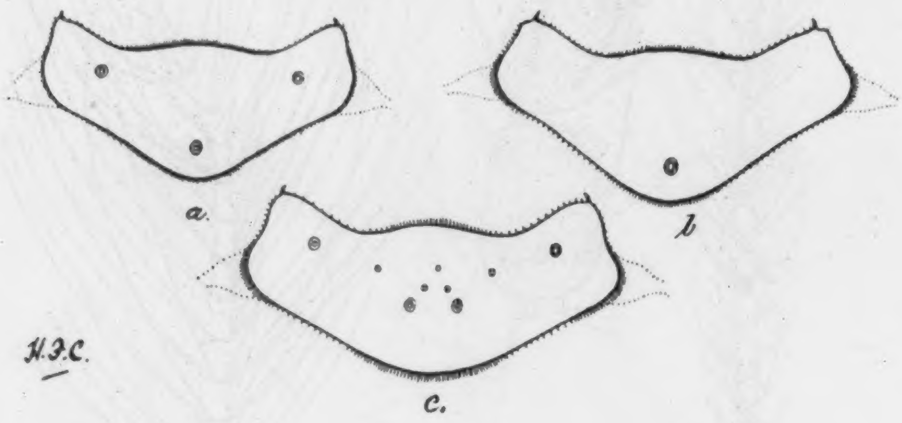

FIG. 5. *C. grahami*, Aust. *a*—scutellum of female; *b*—scutellum of male; *c*—*C. neavei*, Aust., scutellum of female. (× 250.)

length. Oblique whorls, incomplete ventrally, of twelve to twenty hairs are present on each segment from the fourth to the twelfth; the three terminal segments each bear an incomplete basal whorl of seven or eight relatively short hairs, and short hairs scattered over the rest of the surface. Long and short spines are present on each segment from the third to the twelfth; on the thirteenth to the fifteenth segments are several small, curved spines.

Thorax strongly arched anteriorly, but not projecting over the head. Near the anterior margin, one on each side, are two small, slit-like depressions, and immediately in front of the scutellum, are two small, circular, admedian depressions. Dorsum clothed with short hairs. Scutellum (fig. 5), a transverse strip of chitin with the posterior

margin rounded centrally and somewhat concave towards the sides; bearing a few bristles and, in many species, some short hairs. Post-scutellum strongly arched, devoid of hairs, with a small, deep, central depression posteriorly.

Wings usually grey, with darker areas along the anterior border and more or less numerous pale spots on the field. Surface of the wing entirely covered with minute upright setae; longer decumbent hairs are also present, especially towards the apex and along most of the veins and folds. The wings have a beautiful irridescence when light falls on them at certain angles. The fringe is well-developed. Venation as shown in Plates VII and VIII; the first and third veins usually form two small cells, or interspaces, arranged in a figure-of-eight; the extreme base of the lower branch of the fourth vein is obsolete, but so far as can be judged, the vein bifurcates about the middle of the wing; the anterior or radio-medial cross-vein is relatively large, but is often partially obscured by a pale spot. The wing of the male is smaller and narrower than that of the female, and the decumbent hairs are less numerous.

Legs generally infuscated, often with darker knee-spots bounded on each side by a narrow whitish band; the terminal segments of the tarsus rather paler than the rest of the leg. The legs are somewhat thickly clothed with short hairs; the middle pair are longer, the hind pair stouter, than the others. Femora unarmed. Fore tibiae each armed with a short, stout, ventral spur and an oblique row of short, fine bristles at the distal extremity; middle tibiae unarmed; hind tibiae each with a short spur and two transverse rows of bristles apically—the distal row composed of four or five relatively long, stout, graded bristles, the proximal row of about twenty shorter, finer bristles. First tarsal segment twice the length of the second or longer, those of the middle legs distinctly longer and narrower, those of the hind legs stouter and more bristly, than the others; the second to the fourth tarsal segments decrease in length progressively, the fifth segment being as long or slightly longer than the fourth. Apical bristles of the first three tarsal segments of the middle legs differentiated, spine-like. Claws of all the legs equal, rather less than half the length of the fifth tarsal segment, each with a short curved hair arising from its base; claws simple in the female, divided at the tips in the male (fig. 6 *e*).

Empodium in the form of a minute branched hair, often difficult to detect.

Abdomen composed of nine segments clothed with short hairs. Abdomen of the male more slender than that of the female, the hypopygium conspicuous. Lamellae in the female small and rounded. Spermathecae (fig. 6) usually two in number, situated at

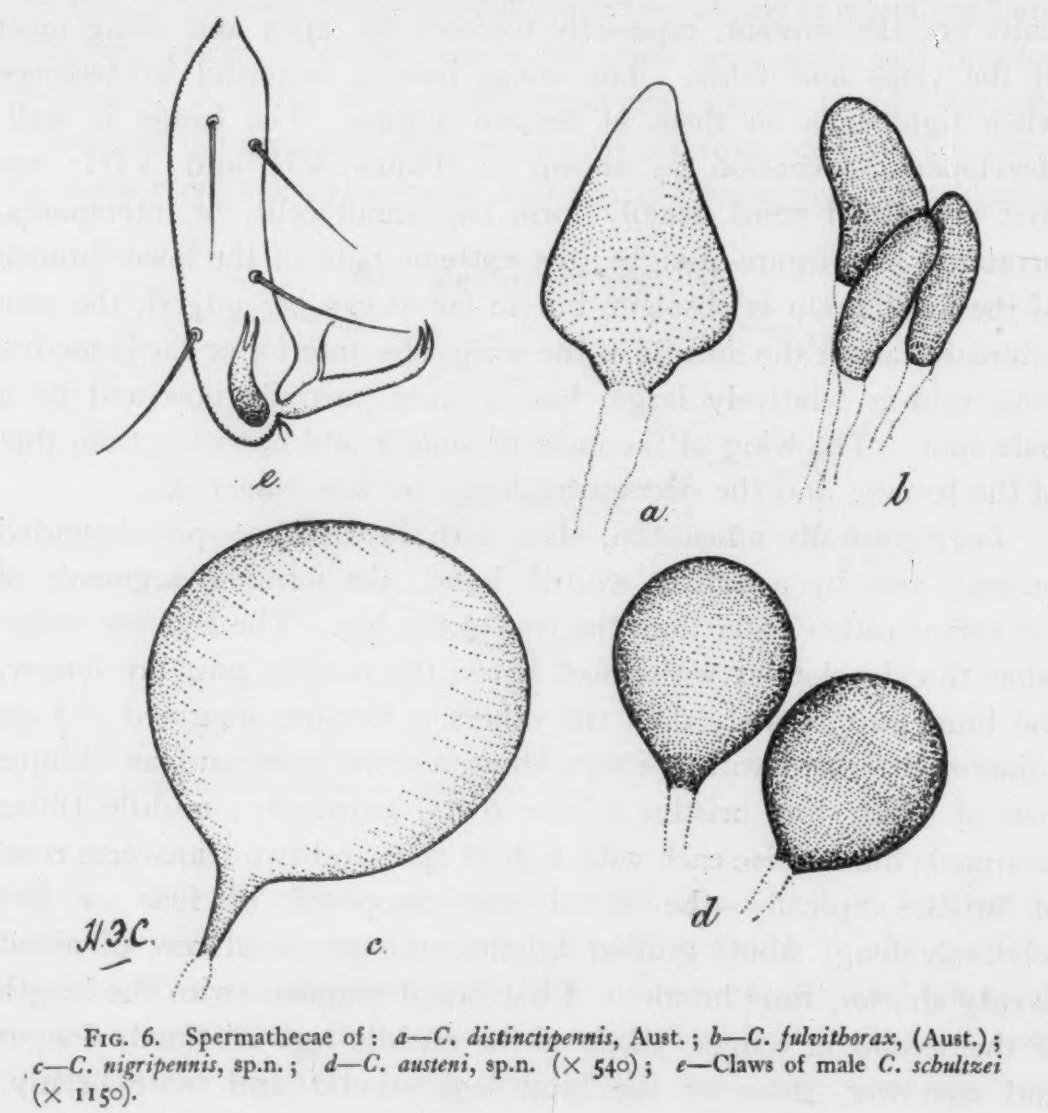

FIG. 6. Spermathecae of: *a—C. distinctipennis*, Aust.; *b—C. fulvithorax*, (Aust.); *c—C. nigripennis*, sp.n.; *d—C. austeni*, sp.n. (× 540); *e*—Claws of male *C. schultzei* (× 1150).

the posterior end of the abdomen, chitinised, oval or nearly spherical in most species; the commencement of the duct is usually chitinised for a short distance.

External genitalia of the male (c.f. figs. 7 and 8). The hypopygium is relatively large and complex, easily distinguishable with the aid of a hand lens. The morphological characters present

specific differences and are of value in distinguishing closely allied species. For the structures composing the hypopygium we have adopted, in part, the nomenclature suggested by Edwards (1920). The *ninth segment* of the abdomen is shaped like an inverted coal-scuttle, the sternite being reduced to a narrow chitinous strip which is usually deeply excavated centrally, the tergite prolonged posteriorly into a broad plate which arches over the basal portions of the forceps and the intermediate appendages. The whole segment is well chitinised. The sternite is devoid of strong hairs ventrally. The tergite narrows somewhat towards its posterior end, is strongly

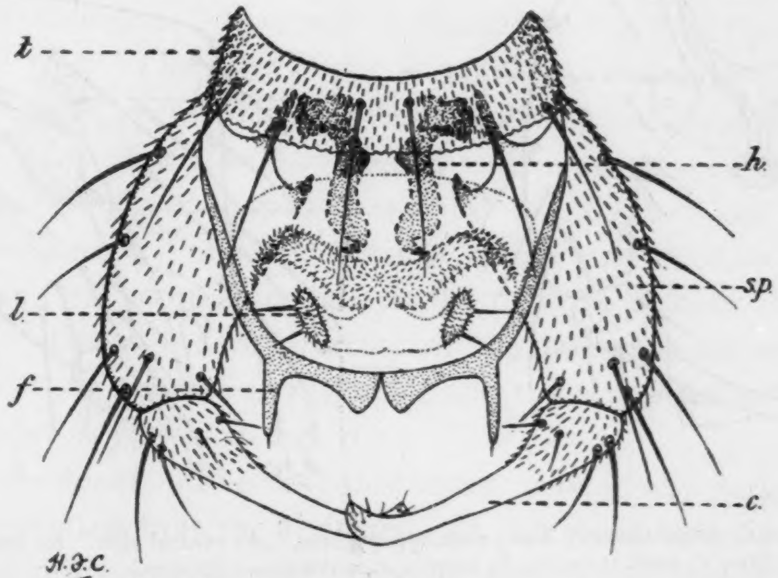

FIG. 7. *C. distinctipennis*, Aust., male hypopygium, dorsal view: *h.*, harpe; *s.p.*, side-piece; *c.*, clasper; *t.*, ninth tergite with the dorsal wall removed posteriorly; *l.*, lobe-like process of ninth tergite; *f.*, finger-like extension of posterior margin of ninth tergite. (× 400.)

chitinised laterally and posteriorly, is sparsely clothed dorsally with strong hairs most numerous on the distal third, and, at its posterior margin, is frequently prolonged on each side into a finger-like structure bearing a minute hair at the apex. The lower surface of the projecting portion of the tergite is lined by membrane which bears apically two lobe-like processes studded with minute spines, intermixed with which are a few short hairs; in some positions of the hypopygium these lobes protrude prominently beyond the posterior margin of the tergite. Anterior to these processes, and situated more ventrally, is a transverse strip of the membrane

covered with spicules which appears to be intimately connected with the distal extremities of the harpes. The anus lies posterior to this strip of membrane—between the bases of the two lobe-like processes. *Forceps* well-developed, highly chitinised. Side-piece (*i.e.*, basal portion of the forceps) large, tapering slightly to the distal extremity; proximal end broad and furnished with one or two highly chitinised root-like internal projections, one of which

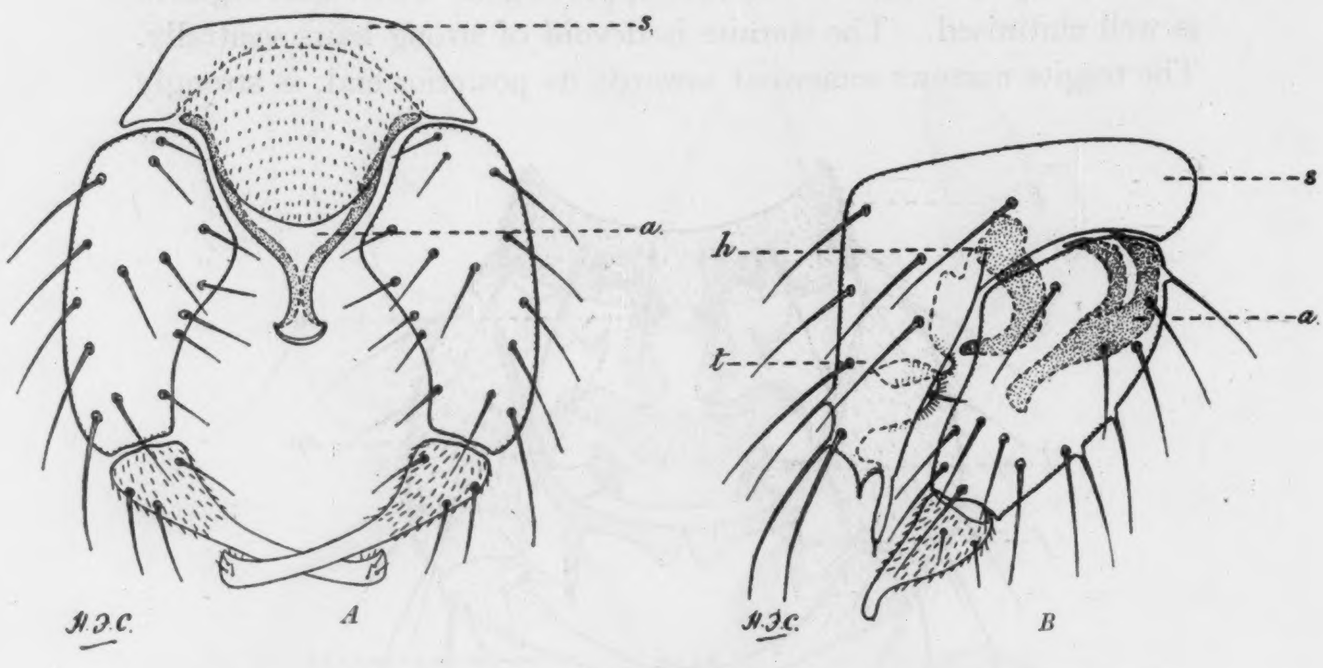

FIG. 8. *C. distinctipennis*, Aust., male hypopygium. *A*—ventral view. *B*—lateral view: *t.*, ninth tergite; *s.*, ninth sternite; *h.*, harpe; *a.*, aedoeagus. (× 400.)

articulates with the basal portion of the harpe of that side; clothed with strong hairs on its ventral and lateral aspects. Clasper almost as long as the side-piece with which it articulates; less highly chitinised than the side-piece, broad at the base narrowing rapidly, and ending in a slightly expanded, usually spoon-like apex; clothed at its base with minute hairs intermixed with a few longer and stouter ones, and bearing at its apex a few minute hairs. *Harpes* in the form of two chitinised admedian plates, each composed of two parts, a shorter root-like proximal portion, and a longer distal portion. The proximal portions articulate with the root-like processes at the bases of the side-pieces; they are often quite insignificant and difficult to distinguish, but sometimes appear as highly chitinised processes attached to the distal portions at right

angles. The harpes vary in shape and size in different species, and are of great value in identification. *Aedoeagus* usually somewhat Y-shaped, situated ventrally, with the stem directed backwards. The stem or distal portion is usually less highly chitinised than the limbs, and is shaped like a gutter. The limbs form a posteriorly directed arch over the ventral excavation in the ninth sternite; they are connected posteriorly and ventrally by a thin chitinous sheet—the ventral wall—which is continued anteriorly by a membrane to the ninth abdominal segment. This membrane is sometimes more or less covered with spicules.

PUPA (fig. 9). The pupa is of the usual type found in the Diptera Nematocera. It is well chitinised and is entirely free from the larval pelt. The integument is granular, and in certain areas is covered more or less densely with small squamose spines. These spines are particularly well-developed on the antero-median portion of the cephalo-thorax (operculum) and on the terminal segment of the abdomen. Tubercles bearing spines and bristles are also present, and are most numerous on the third to seventh abdominal segments. The size and structure of the tubercles are of specific value, and their general arrangement and the nomenclature adopted in this paper is shown in fig. 9 *b*.

Cephalo-thorax. The cephalo-thorax is relatively large and is sharply separated from the abdomen. It is divided by a deep dorsal depression into a cephalic and a thoracic portion; the cephalic portion is situated anteriorly and is but little depressed. The respiratory trumpets (fig. 12) are of moderate length and almost straight. They arise from tubercles situated on the antero-lateral region of the thoracic portion, each tubercle is drawn out distally into a narrow stalk-like portion or pedicle of varying length, with which the base of the trumpet articulates freely. The proximal two-thirds of the trumpets are covered with small squamose spines, and on the inner side of each are a variable number (usually two to four) of more or less conspicuous knobs. The main tracheal trunk runs through the middle of the trumpets and gives off branches to these knobs, at the end of each of which is a minute opening; it terminates in a fan-like arrangement of, usually, six similar branches. The wing- and leg-cases are attached to the sides, and extend backwards as far as the posterior border of the second abdominal segment.

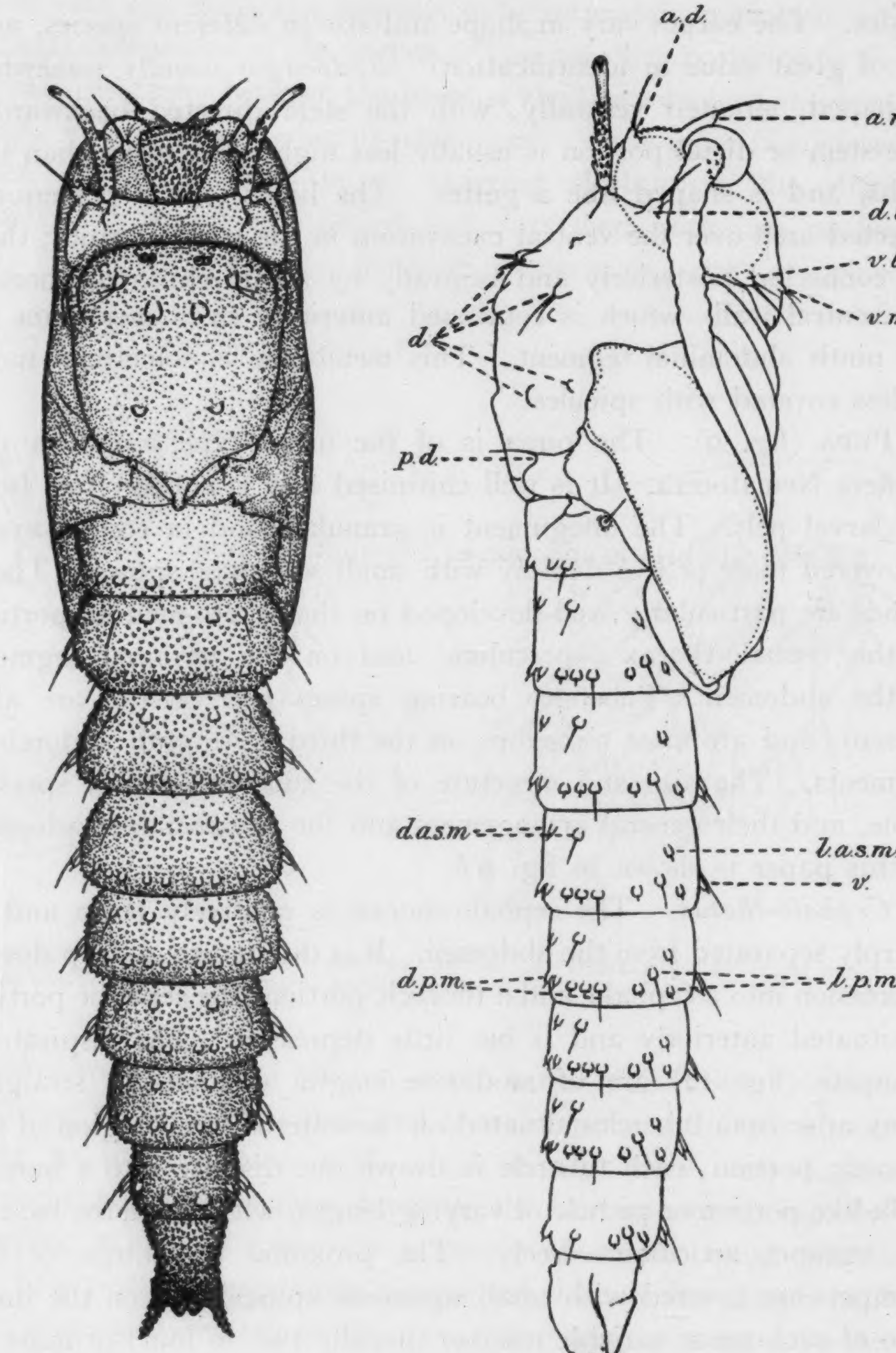

FIG. 9. Pupa of *Culicoides accraensis*, sp.n. (male). *A*—Dorsal view. *B*—Lateral view: *a.m.*, anterior marginal tubercle; *a.d.*, anterior dorsal tubercle; *d.l.*, dorso-lateral tubercle; *v.l.*, ventro-lateral tubercle; *v.m.*, ventro-median tubercle; *d.*, dorsal tubercles; *p.d.*, postero-dorsal tubercle; *d.a.sm.*, dorsal antero-submarginal tubercles; *d.p.m.*, dorsal postero-marginal tubercles; *l.a.sm.*, lateral antero-submarginal tubercle; *l.p.m.*, lateral postero-marginal tubercles; *v.*, ventral tubercles. (× 85 *circa*.)

Both the cephalic and thoracic areas bear tubercles, and the following may be distinguished on each side of the body:—

Anterior-marginal. Situated anteriorly and slightly ventrally near the middle line, just internal to that part of the integument overlying the two basal segments of the antenna of the enclosed insect. It is a long conical tubercle directed laterally and bearing a moderately long stout bristle.

Anterior-dorsal. Situated slightly external and posterior to the antero-marginal tubercle and on the upper margin of the eye of the imago. It bears a short stout bristle and a minute spine.

Dorso-lateral. Situated just in front of, and external to, the base of the respiratory trumpet and dorsal to the antenna of the imago. It is a small tubercle of variable shape, and is provided with a delicate bristle and one or two minute spines.

Ventro-lateral. A somewhat inconspicuous rounded hump situated near the lower margin of the eye of the enclosed insect. Two or three delicate bristles of varying length arise from the apex.

Ventro-median. Situated near the middle ventral line of the cephalic area, immediately internal to the third segment of the palp of the adult. This tubercle is very small and inconspicuous, and may be represented only by the one or two small delicate setae which it bears.

Dorsal. A variable number of tubercles situated on the central portion of the thoracic region, above the mesothorax of the enclosed insect. Some of these tubercles are rudimentary and devoid of bristles or spines, but at least three well-developed tubercles are present on each side of the middle line. These lie above the anterior portion of the mesothorax and form a triangle with the apex pointing laterally.

Postero-dorsal. A small tubercle bearing a delicate seta, situated immediately external to the post-scutellum of the imago,

Abdomen flexible and capable of a considerable range of movement but normally extended directly backwards. It consists of nine well-marked segments, and is broad at the base, gradually narrowing towards the apex. The first is slightly shorter than the others, the last elongate and the intermediate segments sub-equal in length. The last segment terminates in two curved, divergent, lateral processes with sharply pointed tips which are directed dorsally;

these processes are merely highly developed lateral tubercles. In the male the terminal segment is furnished ventrally with cases for the forceps. The abdominal tubercles are somewhat flattened and, on segments three to seven, may be separated into dorsal, lateral (actually ventro-lateral), and ventral groups. The dorsal and lateral groups each consists of two series of tubercles, the postero-marginal and the antero-submarginal. The ventral group consists of postero-marginal tubercles only. The lateral tubercles are the most highly developed, the other tubercles become smaller the nearer they approach the middle line of the body.

Postero-marginal. The dorsal group usually consists of five tubercles, the outer three of which are sometimes slightly separated from the inner two. The lateral and ventral groups each consists of three tubercles.

Antero-submarginal. The dorsal group consists of two tubercles, the lateral group of one, which is situated almost directly over the lowest postero-marginal.

On the first, second and eighth segments the number of tubercles is reduced; the ninth segment is devoid of bristle-, or spine-bearing tubercles. The abdominal tubercles usually bear delicate setae, short stout spines, or minute spines. These setae and spines, however, are slightly variable, and some of the tubercles, especially the inner members of the dorsal postero-marginal row, occasionally appear to be unarmed.

LARVA (fig. 10). The mature larvae are long (2 to 5 mm.) and slender, and are white or creamy-white in colour with yellowish-brown heads.

Head relatively small, sub-conical, convex on the dorsal and rather flattened on the ventral aspect, bearing a few small dorsal, lateral, and ventral hairs arranged as shown in the figure.* Dorsally the head capsule is divided into three plates—a median (clypeal) and two lateral (epicranial)—by sutures, along the lines of which rupture occurs. The eyes are heavily pigmented, and each consists of a small, sometimes separate, anterior portion, and a large posterior portion; normally they are situated laterally, just behind the middle of the head, but in larvae which are approaching pupation they are retracted, and not infrequently may be observed on, or near, the

* Two pairs of minute hairs (not shown in the figure) are present near the posterior dorsal margin.

posterior margin of the head (c.f. fig. 10, 3). The antennae are represented by minute membranous structures situated near the

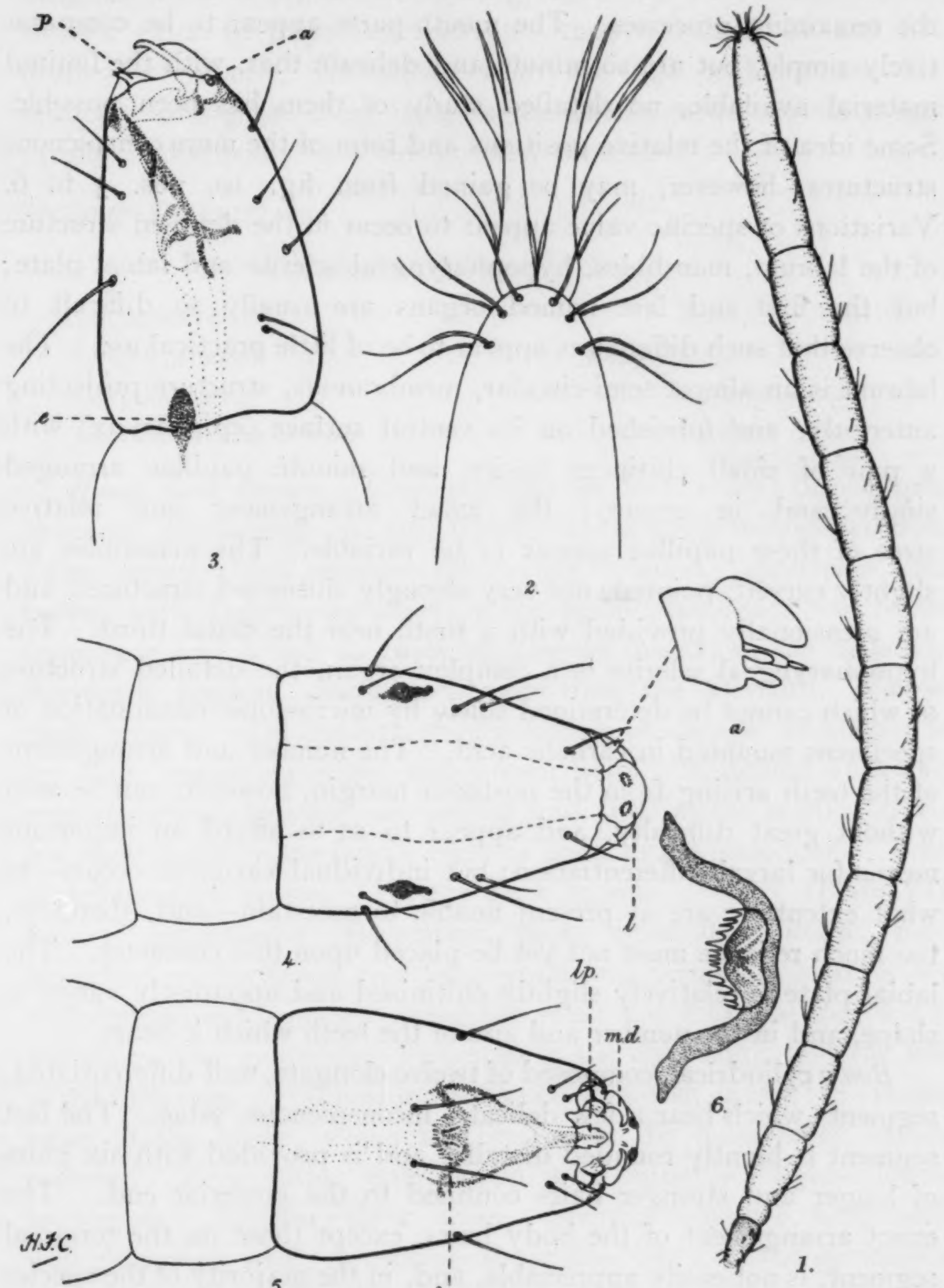

FIG. 10. *C. accraensis*, sp.n. 1—Mature larva (× 48). 2—last segment with anal. gills extended (× 160). 3—head, lateral view : *a.*, antenna ; *p.*, palp ; *e.*, eye (× 360). 4—head, dorsal view : *a.*, antenna of *C. nigripennis*, sp. n. (lateral view greatly enlarged) ; *l.*, labrum (× 360). 5—head, ventral view : *md.*, mandible ; *lp.*, labial plate ; *hp.*, hypopharyngeal sclerite (× 360). 6—hypopharyngeal sclerite (anterior teeth omitted) (× 930).

anterior extremity ; the apex bears a relatively large lobe and three small sub-cylindrical processes, one of which carries a delicate spine.

The lobe-like process occupies a dorsal position and, when the antenna is seen from above, almost obscures the basal portion and the remaining processes. The mouth-parts appear to be comparatively simple, but are so minute and delicate that, with the limited material available, no detailed study of them has been possible. Some idea of the relative positions and form of the more conspicuous structures, however, may be gained from fig. 10, nos. 3 to 6. Variations of specific value appear to occur in the detailed structure of the labrum, mandibles, hypopharyngeal sclerite and labial plate; but the first and last named organs are usually so difficult to observe that such differences appear to be of little practical use. The labrum is an almost semi-circular, membranous, structure projecting anteriorly, and furnished on its ventral surface (epipharynx) with a pair of small chitinous hooks, and minute papillae arranged singly and in groups; the exact arrangement and relative sizes of these papillae appear to be variable. The mandibles are slightly curved, pointed, not very strongly chitinised structures, and are occasionally provided with a tooth near the distal third. The hypopharyngeal sclerite is a complex organ, the detailed structure of which cannot be determined solely by microscopic examination of specimens mounted in carbolic acid. The number and arrangement of the teeth arising from the posterior margin, however, can be seen without great difficulty, and appear to us to afford an important means for larval differentiation; but individual variation occurs—to what extent we are at present unable to ascertain—and, therefore, too much reliance must not yet be placed upon this character. The labial plate is relatively slightly chitinised and apparently varies in shape, and in the number and size of the teeth which it bears.

Body cylindrical, composed of twelve elongate, well-differentiated, segments which bear a few delicate, inconspicuous, setae. The last segment is bluntly rounded distally, and is provided with six pairs of longer and stronger hairs confined to the posterior end. The exact arrangement of the body hairs, except those on the terminal segment, is not easily appreciable, and, in the majority of the species examined, they were not found to be of any systematic importance. Immediately behind the head is a small, but distinct, segmental-like constriction which gives the body the appearance of being composed of thirteen segments. This apparently is the neck;

it is entirely devoid of hairs, and in mature larvae the presence of imaginal buds in the three following segments, which become much swollen prior to pupation, indicates that it cannot be the first thoracic segment. Extending from the last segment are four retractile anal gills; these are elongate membranous structures each deeply cleft distally into two pointed processes.

SPECIFIC DESCRIPTIONS

Culicoides inornatipennis, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body*	1·1 mm.	1·0 mm.
Length of wing	0·9 mm.	0·8 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

Head dark brown. Eyes separate in both sexes, the internal chitinous thickening in the female distinct. Proboscis brown. Palpi brown, third segment moderately inflated. *Antennae* dark brown, with dark brown hairs; in the female, segments four to ten from once and a half to twice as long as broad; in the male, the thirteenth segment distinctly longer than the fifteenth. *Thorax* dark brown, with distinct greyish-brown markings as shown in fig. 22 *c*; sparsely clothed with brown hairs. Scutellum uniformly greyish-brown; bearing one central and two lateral bristles and a few short hairs (in the female eight or nine, in the male four). Post-scutellum dark brown. Pleurae dark brown. *Wings* (Plate VII, fig. 1) unspotted. Decumbent hairs moderately dense, most abundant on the apical anterior portion and present in more or less well-defined rows, mainly along the veins and folds, to the base of the wing; also moderately numerous in the anal angle and the fork of the fifth vein. Halteres in the female yellowish except the extreme bases of the knobs, which are brown; in the male paler, cream-coloured. *Legs* rather pale brown with indistinct light-coloured knee-spots. *Abdomen* dark brown. Spermathecae two, moderately well chitinised, oval, measuring about 40μ by 30μ; the commencement of the duct only, chitinised.

HYPOPYGIUM (fig. 11). Relatively slightly chitinised. *Ninth segment*: posterior margin of the tergite notched in the middle,

* Unless otherwise indicated this measurement is made from specimens mounted in carbolic and is taken from the anterior margin of the thorax to the posterior end of the abdomen. *Vide* foregoing paper—Part I—p. 192.

and extended on each side into a very long and narrow (length approximately seven times the width in the middle) finger-like process. *Forceps*: side pieces and claspers normal. *Harpes* (fig. 20, *g*) simple, the distal extremities very narrow and twisted in a ventral direction; proximal portions more strongly chitinised and placed almost at right angles to the terminal portions. *Aedoeagus* Y-shaped, gradually tapering to a distal, rather broad, gutter-like process with a blunt apex; the limbs more strongly chitinised, with everted proximal extremities, forming a relatively narrow and pointed arch above the ninth sternite. The membrane connecting the ventral wall of the aedoeagus with the ninth sternite is devoid of spicules.

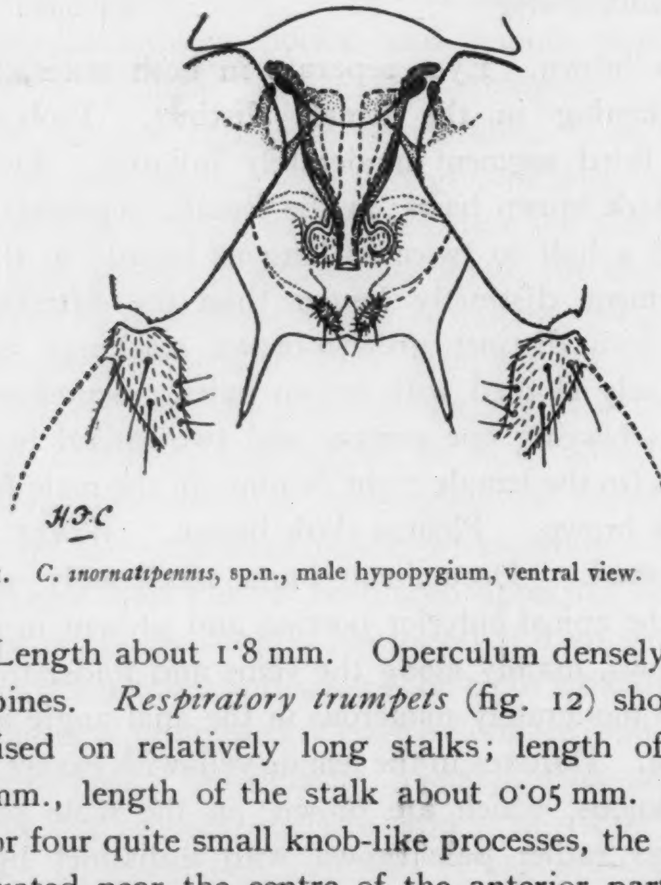

FIG. 11. *C. inornatipennis*, sp.n., male hypopygium, ventral view. (× 400.)

PUPA. Length about 1·8 mm. Operculum densely covered with squamose spines. *Respiratory trumpets* (fig. 12) short and nearly straight, raised on relatively long stalks; length of the trumpet about 0·14 mm., length of the stalk about 0·05 mm. The trumpet bears three or four quite small knob-like processes, the most distal of which is situated near the centre of the anterior part. The main tracheal trunk terminates distally in a fan-like group of short blunt processes. *Cephalo-thorax*. Anterior marginal tubercle rather small, conical, bearing a relatively long, stout, spine; anterior dorsal tubercle prominent, rounded, bearing a stout spine and a minute spine; dorso-lateral tubercle small, conical, bearing a hair and a minute spine; ventro-lateral tubercle a rounded hump, bearing a

long and a moderately long hair; ventro-median tubercle very small, bearing a small hair. Dorsal tubercles: anterior double, the two parts being separate and well-developed but not large knobs, each bearing a stout spine; posterior, feebly developed, bearing a short spine; lateral bearing a hair. In front of the anterior tubercle and a little external to it is an inconspicuous unarmed tubercle. Postero-dorsal tubercle small, bearing a long hair. *Abdomen.* Anal segment with sharply pointed terminal processes. The dorsal and lateral tubercles (fig. 12) on the abdominal segments are rather

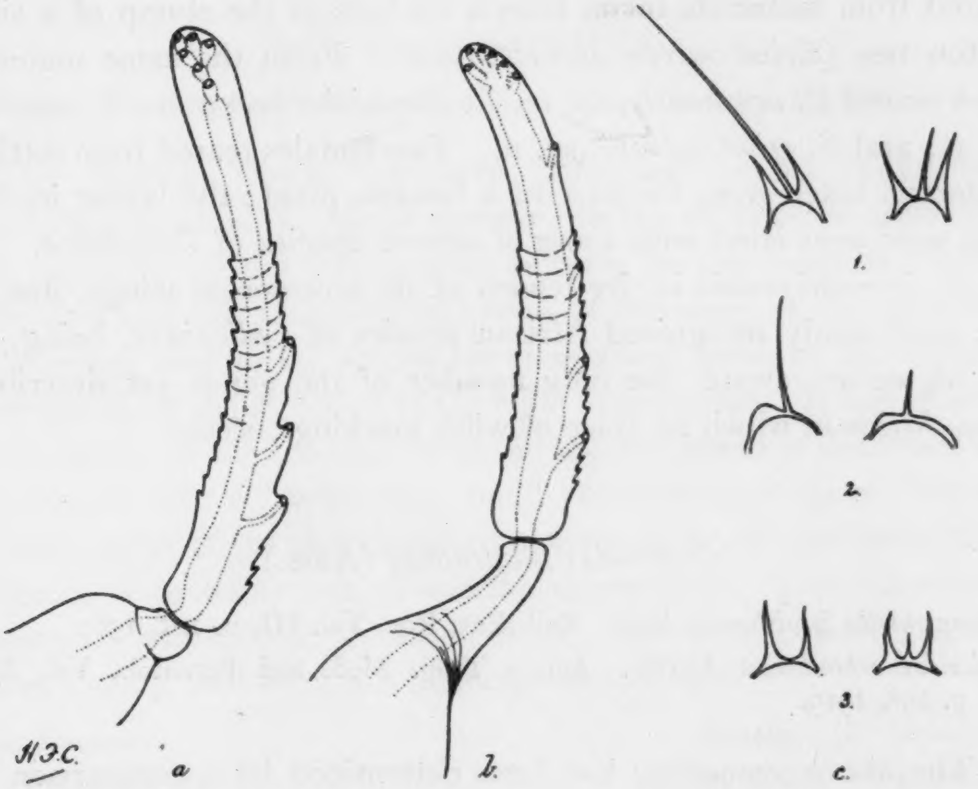

FIG. 12. *a*—Respiratory trumpet of pupa of *C. accraensis*, sp.n.; *b*—trumpet of *C. inornatipennis*, sp.n.; *c*—types of abdominal tubercles of pupa of *C. inornatipennis*, sp.n. 1—lateral; 2—ventral; 3—dorsal (postero-marginal). (*a* and *b* × 360, *c* × 450.)

small, each with two sharp points between which are the hairs or spines. Dorsal tubercles: antero-submarginal, the inner bearing a short spine and the outer a hair; postero-marginal four only in number; the inner and the outer bearing spines, the two middle tubercles apparently unarmed. Lateral tubercles larger than the others: antero-submarginal, bearing a spine; postero-marginal, the middle one bearing a hair, the other two, spines. Traces are

sometimes visible of a second, rudimentary, antero-submarginal tubercle. Ventral tubercles of normal form: the middle one bearing a hair, the other two, spines.

LARVA. The larva is of the usual *Culicoides* type, vermiform, aquatic, very active; head well chitinised, yellow; body cylindrical, almost white, very sparsely clothed with hairs, and with the usual anal appendages. Details unfortunately cannot be given, as we were not so fortunate as to find the pelt of the only larva which was isolated and successfuly bred through.

HABITAT: Nsawam, Gold Coast, April, 1920. A single male reared from materials taken from a rot-hole in the stump of a silk-cotton tree (*Eriodendron anfractuosum*). From the same material were reared *C. accraensis*, sp. n., *C. punctithorax*, sp. n., *C. clarkei*, sp. n., and *C. eriodendroni*, sp. n. Two females reared from rotting materials taken from the base of a banana plant; the larvae in this case were associated with those of several species of *Dasyhelea*.

C. inornatipennis is, by reason of its unicolorous wings, one of the most easily recognised African species of *Culicoides*, being, so far as we are aware, the only member of the genus yet described from Africa in which no trace of wing markings occurs.

Culicoides fulvithorax (Aust.)

Johannseniella fulvithorax, Aust. Bull. Ent. Res., Vol. III, p. 105, 1912.
Culicoides ochrothorax, Carter. Annals Trop. Med. and Parasitol., Vol. XII, p. 298, 1919.

The above synonymy has been determined by a comparison of the types. One female only of this striking species has been obtained during this investigation and, in view of the descriptions already published, only the following characters need be noted.

MEASUREMENTS.

Length of body	1·0 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·4 mm.

The eyes are broadly contiguous dorsally. The third segment of the palp is moderately expanded and is normal, the description given by Carter apparently being made from a preparation

which had been subjected to pressure. The fourth to tenth segments of the antennae are elongate, sub-cylindrical, from two to nearly three times as long as wide. The scutellum bears three bristles, one central and two lateral, and is devoid of short hairs. The spermathecae are of unusual form and, in the single specimen examined, are three in number; they are somewhat sausage-shaped and of unequal sizes (fig. 6).

HABITAT: Accra, Gold Coast. Taken in the evening on a window of the laboratory.

Culicoides schultzei (End.)

Ceratopogon schultzei, End. Denks. Med. Ges. Jena, Vol. I, pp. 155-162, 1908.

The species which we have identified with Enderlein's *C. schultzei* from S.W. Africa agrees with the description given by that author in all essential points, notably in the complete fusion of the first and third longitudinal veins of the wing, in the spotting of the wing, and so far as can be determined from the incomplete figure given, in the structure of the male hypopygium. It apparently differs chiefly in the colouration of the thorax, which is described as deep brown with a few distinct small yellowish-grey spots; but as the colouration of the thorax varied somewhat in our specimens this difference is probably not of specific importance. The differences between *C. scultzei* and *C. kingi*, Aust., have been pointed out by Austen (1912), and need not be recapitulated here.

MEASUREMENTS.	Female.	Male.
Length of body	1·4 mm.	1·5 mm.
Length of wing	1·1 mm.	0·9 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

Head grey; nape and occiput dark brown, with dark hairs; frons grey; clypeus pale brown. Eyes separate, the internal chitinous thickening distinct in the female. Proboscis pale brown. Palpi brown; the third segment considerably swollen and not attenuated anteriorly; the fourth segment relatively short, distinctly shorter than the fifth. *Antennae* (fig. 4 *a* and *b*): Torus dark brown, flagellum segments brown, the basal segments (four to ten) in the female stout, ovoid, from one and one-third to one and

one-half times as long as broad; in the male the terminal segment longer than either of the two preceding segments. *Thorax* drab-grey, with many dark, sepia-coloured spots and blotches arranged as in the figure (fig. 22 *d*). The sizes of the spots and patches vary—in most specimens the thorax is predominantly grey, but in some it is predominantly dark brown; in the male the dark markings are larger and more conspicuous than in the female. Scutellum brown in the centre, grey laterally, bearing two long dark bristles in the middle and one on each side; short hairs absent. Post-scutellum dark brown. Pleurae drab-grey like the dorsum of the thorax, and similarly marbled with dark brown markings. *Wings* grey to brownish-grey, darker along the anterior border, with numerous sharply-defined pale spots as shown in the figure (Plate VII, fig. 2). The wing markings are rather variable, for example, the four spots in the apical portion of the wing are sometimes entirely separate, occasionally completely united forming a semicircular pale area, but most commonly as shown in the figure. The anterior margin bears three dark spots—the first, and darkest, a rectangular patch situated in the middle of the wing at the junction of the first and third longitudinal veins with the costa, the second, a paler and more diffuse spot, situated about midway between the first dark spot and the apex of the wing, the third, a larger but less distinct spot than either of the other two, situated towards the base of the wing. In the male (Plate VII, fig. 2 *a*) the dark spot in the middle of the anterior border is distinctly shorter and more nearly square than in the female, and the proximal pale spot longer. Venation as shown in the figure; first and third longitudinal veins *completely fused*, so that the characteristic cells usually formed by these veins are absent. Wings sparsely clothed with decumbent hairs, which are most numerous on the distal third, at the anterior margin, and along the veins. Halteres each with the apical half of the knob cream-coloured, the proximal half and stem dark. *Legs* pale brown, with dark knee-spots and pale bands on either side of these spots. Femora with dark tips, above each of which is a narrow pale band; proximal portion pale brown, becoming more dusky towards the pale band. Tibiae with bases very narrowly dark followed by a narrow whitish band, and a slightly broader dusky

band which reaches to about the middle; apical half of the tibia pale brown with the extreme apex dark brown. First tarsal segments slightly infuscated, other tarsal segments pale brown. *Abdomen* dark brown, clothed with short dark hairs. Spermathecae two, rounded or slightly longer than broad, diameter about 50μ by 45μ, dark and highly chitinised; only the extreme end, about 4μ, of the duct is chitinised.

HYPOPYGIUM (figs. 13 and 14). *Ninth segment:* sternite deeply excavated centrally; tergite relatively long and narrow posteriorly, finger-like extensions and apical lobe-like processes well-developed.

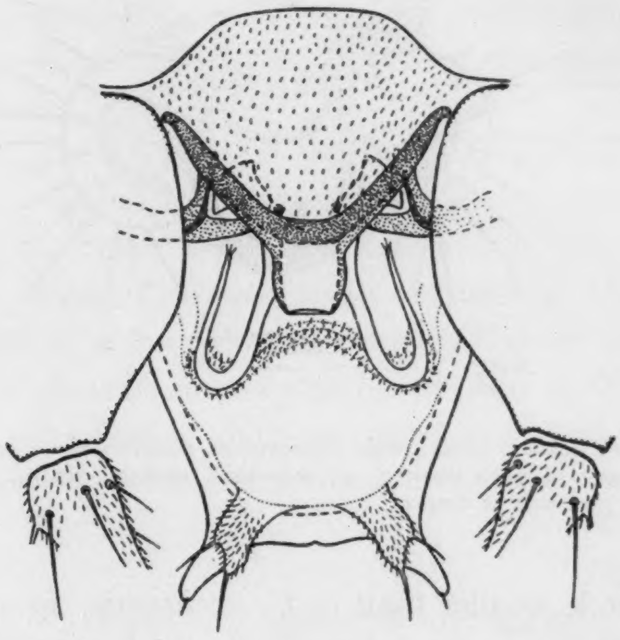

FIG. 13. *C. schultzei* (End.), male hypopygium, ventral view. (× 400.)

Forceps: side-piece with two basal chitinous processes projecting inwards; clasper clothed with minute hairs for the greater portion of its length, and with some of the stronger basal hairs unusually long. *Harpes* (fig. 20 *h*) in the form of two unbranched, long, narrow, tapering chitinous structures with sinuous outlines; they are bent ventrally, almost at a right angle, near the middle, and distally each is finely rounded and bears three or four minute hairs. *Aedoeagus* broad at the base, narrowing at its posterior third to form a straight, broad, gutter-like process directed backwards and furnished with a ventral lip of thin chitin; in ventral view this lip

is very difficult to detect, and the extremity of the aedoeagus appears to be notched.

PUPA. Length about 2 mm. *Respiratory trumpets.* Length about 0·2 mm. Distal ends darkened, middle portions closely ringed, lower portions bearing two or three knob-like processes. The main tracheal trunk terminates distally in a fan-like arrangement of about six short blunt processes. *Cephalo-thorax*: anterior

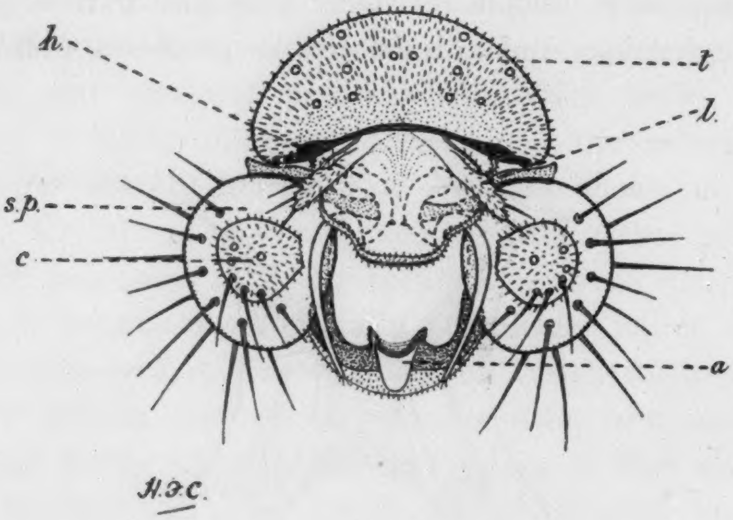

FIG. 14. *C. schultzei* (End.), male hypopygium, posterior view: *t.*, ninth tergite; *l.*, lobe-like process of ninth tergite; *a.*, aedoeagus, showing ventral lip; *b.*, harpe; *s.p.*, side-piece; *c.*, base of clasper. (× 400.)

marginal tubercle smaller than in *C. accraensis*, sp. n. (c.f. fig. 9), bearing a short stout spine; anterior dorsal larger, conical, bearing a short, stout, spine and a minute spine; dorsal-lateral small, bearing a short hair; ventro-lateral small, bearing a short hair; ventro-median tubercle absent, but represented by a single minute hair. Dorsal tubercles: as in *C. accraensis*. Postero-dorsal tubercle small, bearing a minute hair and, apparently, a minute spine. *Abdomen*: anal segment with squamose spines almost confined to the anterior region; tips of the terminal processes dark. Dorsal tubercles: as in *C. accraensis*, but smaller. Lateral tubercles: as in *C. accraensis*, but smaller. There is an additional tubercle, most distinct on the apical segments, situated above the central postero-marginal tubercle. Ventral tubercles: as in *C. accraensis*, but smaller.

LARVA. Length 2 mm. to 2·9 mm., average of five 2·4 mm. Greatest breadth 0·14 mm. to 0·19 mm., average 0·15 mm.

Head, length about 0·1 mm., greatest breadth about 0·09 mm. Eyes large, bilobed. Bristles extremely small, apparently arranged as in *C. accraensis*. Mental plate very slightly chitinised and difficult to see, situated rather more posteriorly than in *C. accraensis*, more or less semicircular, bearing on each side apparently one large and four small teeth. Hypopharyngeal sclerite (fig. 21 *e*) rather heavily chitinised, moderately large, bearing on each side three pointed processes, the middle one being large and broad. Mandibles simple, pointed. *Body* appearing almost hairless, but actually bearing a few very minute hairs; terminal hairs on the anal segment very small, but, as far as can be determined, arranged as in *C. accraensis*.

HABITAT: Accra, Odorkor and Oblogo, Gold Coast. Collected in the evening upon the windows of the laboratory from December, 1919, to April, 1920; abundant throughout this period and the species most frequently found in this situation. A few specimens taken at night in a bungalow at Accra. Larvae and pupae found at Odorkor in puddles near a stand-pipe, and at Oblogo in a backwater of the river Densu which was used as a washing-place. Also reared from rotting wood taken from canoes lying in the river Densu at Oblogo.

Culicoides punctithorax, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·5 mm.	1·5 mm.
Length of wing	1·1 mm.	1·1 mm.
Greatest breadth of wing	0·4 mm.	0.3 mm.

Head dark brown, occiput brown with brown hairs. Eyes in both sexes narrowly separate, internal chitinous thickening in the female distinct. Proboscis brown. Palpi dark brown, third segment moderately swollen. *Antennae* brown; first segment in the female unusually prominent, as large as the torus, dark brown; torus dark brown; flagellum segments rather darker brown than usual. In the female, segments four to ten oval, of almost equal lengths, each about one and a half times as long as broad; segments eleven

to fifteen distinctly shorter than usual, from two to three times as long as broad; terminal segments (thirteen to fifteen) of the male antenna relatively short, particularly the last, which is distinctly shorter than the thirteenth. *Thorax* dark brown with conspicuous light grey markings on which are numerous small dark spots, as shown in fig. 22 *b*. Scutellum dark brown with greyish lateral areas, bearing two central and two lateral bristles and a number (twelve or thirteen) of short hairs. Post-scutellum dark brown. Pleurae dark brown. *Wings* grey, rather darker along the anterior border, the middle part of which is the darkest portion of the wing. Venation and pale markings arranged as shown in the figure (Plate VII, fig. 4). Wings thickly clothed with decumbent hairs. Halteres with cream-coloured knobs, the stems pale brown. *Legs* brown, tarsal segments rather paler; there are pale bands, less distinct in the male, on each side of the dark knee joints of all the legs, those on the bases of the tibiae being the more distinct. *Abdomen* dark brown, with brown hairs. Spermathecae two, rather highly chitinised, oval, measuring about 48μ by 38μ; the chitinised commencement of the duct short and conical.

HYPOPYGIUM (fig. 15). *Ninth segment*: posterior margin of the tergite notched centrally and bearing on each side a finger-like extension of great length—from eight to nine times as long as the width in the middle. *Forceps*: side-piece stout, clothed laterally with rather longer and stronger hairs than usual; distal extremity of the clasper rounded, with a somewhat irregular margin. *Harpes* (fig. 20 *f*) simple, rather strongly chitinised; proximal portion more strongly chitinised and directed laterally at a right angle to the distal portion, the latter broad basally, tapering posteriorly, with the apical fourth bent ventrally. *Aedoeagus* forming a rather narrow arch over the depression in the ninth sternite, tapering gradually to a relatively broad, straight, distal portion; the extremity consists of a larger central lobe and two small lateral lobes, the central lobe is an extension of the floor of the gutter and is apparently analogous to the ventral lip seen in *C. schultzei* (fig. 14), although less well-developed. The membrane connecting the chitinised ventral wall of the aedoeagus with the ninth sternite is devoid of spicules.

PUPA. Length about 2·4 mm.; operculum covered with dense

sharp-pointed squamose spines. *Respiratory trumpets* arise from relatively long stalks; length about 0·2 mm. They are of nearly the same diameter throughout, and bear two or three very small blunt knobs. The main tracheal trunk terminates distally in a fan-like arrangement of about six short blunt processes. *Cephalo-thorax*: Anterior marginal tubercle large, conical, bearing a very strong, stout, spine which is short or of moderate length; anterior dorsal large, conical, bearing a stout hair and a short spine; dorso-lateral bearing a long hair and a short spine; ventro-lateral large, rounded, bearing a long and a short hair;

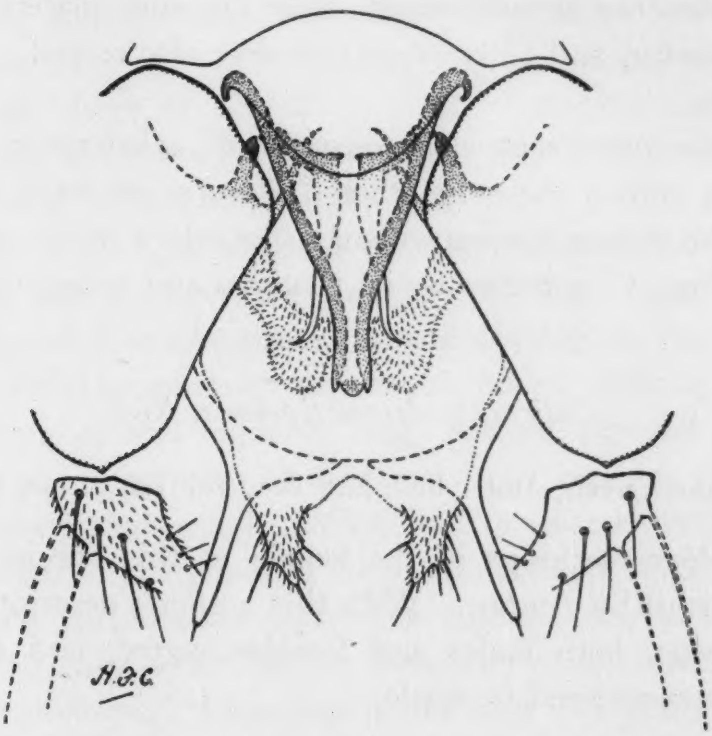

FIG. 15. *C. punctithorax*, sp.n., male hypopygium, ventral view. (× 400.)

ventro-median very small but quite definite, bearing a long and a very short hair. Dorsal tubercles: anterior, the largest, bearing a short stout spine, posterior bearing a long hair, lateral bearing a long hair; behind the posterior is a small tubercle bearing a short spine; in front of the anterior, and rather lateral to it, is a rounded unarmed hump. Postero-dorsal tubercle bearing a long hair; behind it and nearer to the middle line is a small unarmed tubercle. *Abdomen*: Anal segment normal; the other segments furnished with moderately well-developed tubercles. Dorsal

tubercles: antero-submarginal, the inner bearing a relatively long spine, and the outer a long hair; postero-marginal, the outermost bearing a long hair, the second a stout spine, and the inner three minute spines. Lateral tubercles: antero-submarginal, bearing a stout spine; postero-marginal, the middle one bearing a long hair, the other two stout spines. Ventral tubercles: the middle one bearing a long hair, the other two short spines.

LARVA. The larva of this midge has not yet been identified.

HABITAT: Nsawam, Gold Coast, a station about twenty-five miles north of Accra, at the edge of the thick forest region. Reared from materials collected in a rot-hole in the stump of a silk-cotton tree (*Eriodendron anfractuosum*); from the same material *C. accraensis*, *C. clarkei*, and *C. eriodendroni* were also reared. March and April, 1920.

C. punctithorax somewhat resembles *C. schultzei* in its thoracic adornment, and is the only other *Culicoides* we have encountered in which the thorax is conspicuously spotted; it is, of course, easily separable from *C. schultzei* by its venation and wing markings.

Culicoides distinctipennis, Aust.

Culicoides distinctipennis, Aust. Bull. Ent. Res., Vol. III, p. 101, 1912.

The colour markings of the female of this species have been given in detail by Austen. With this author's description of them our specimens, both males and females, agree, and therefore no further references need be made.

MEASUREMENTS.	Female.	Male.
Length of body	1·1 mm.	1·1 mm.
Length of wing	1·0 mm.	0·9 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

The eyes of the female are narrowly separate above, the internal transverse chitinous thickening being distinct (fig. 1 *a*); in the male the eyes are more widely separate dorsally (fig. 1 *b*), their opposing edges not parallel, and the distance between them at the vertex greater. Second and third palpal segments (fig. 3 *b*) sub-equal, each about twice the length of any of the other three; the third segment

moderately inflated. Antennal segments four to ten in the female sub-spherical to oval (1-1½ × 1); the thirteenth antennal segment of the male (fig. 4 *c*) slightly longer than either of the two succeeding segments. Scutellum in the female bearing two central and two lateral bristles and six or seven short hairs; in the male with bristles as in the female but only two short hairs. Wings with pale spots as shown by Austen; venation normal. The wing of the male is smaller and narrower than that of the female; the decumbent hairs less numerous but extending as far towards the base of the wing. Spermatheca single (fig. 6 *a*), not very highly chitinised in any part and quite delicate at its distal end, shaped like a peg-top, the duct wide and chitinised for only a very short distance at its commencement.

HYPOPYGIUM (figs. 7 and 8). *Ninth segment*: sternite with the excavation moderately deep; tergite well-developed, sparsely clothed dorsally with strong hairs, most numerous on the distal third, posterior margin notched in the middle and produced on each side into a finger-like structure bearing a minute hair at its apex. Apical lobe-like processes well-developed, the transverse strip of spiculated membrane conspicuous, folded laterally, the folds often appearing at first sight as long, narrow, pointed spiculated lobes. *Forceps*: side-pieces of the usual form; claspers rather more highly chitinised than usual, clothed with minute hairs intermixed with a few longer, stouter, ones on the proximal third, and terminating in a depressed and shallow spoon-like apex bearing a few minute hairs. *Harpes* (fig. 20 *d*): in the form of two unbranched, short, stout, highly chitinised, admedian plates each with the proximal or basal portion expanded, and the distal portion short, terminating in a sharply pointed hook with the point directed laterally. *Aedoeagus* Y-shaped; the stem or distal portion short and broad, less highly chitinised than the limbs and ending in a broad mushroom-shaped structure; the limbs slightly everted basally, forming an arch over the depression in the ninth sternite which is low and wide with the apical angle rounded. The membrane connecting the arch of the aedoeagus with the ninth abdominal segment is covered with spicules.

HABITAT: Accra, Gold Coast. Collected in the evening upon the windows of the laboratory, December, 1919, to April, 1920.

Culicoides praetermissus, sp. n.

This species is very closely allied to *C. distinctipennis*, Aust., and is described from a single male which had been preserved in alcohol together with several examples of *C. distinctipennis*. In due course an examination of the hypopygium of this specimen revealed its distinctiveness, and although we are unable to give any details of the ornamentation of the thorax, the wing markings remained visible and showed slight differences which will probably enable both sexes of the species to be identified without great difficulty.

MEASUREMENTS.

Length of body	1·0 mm.
Length of wing	0·75mm.
Greatest breadth of wing	0·3 mm.

Eyes separate, much as in *C. distinctipennis*. Thirteenth and fifteenth antennal segments sub-equal. Scutellum bearing two central and two lateral bristles, and two short hairs immediately above the central pair of bristles. Wing venation and markings as shown in Plate VII, fig. 3. The markings are very similar to those of *C. distinctipennis* but differ chiefly in the presence of an additional small, pale, spot situated just beyond and below the conspicuous spot at the end of the costa, and apparently in the smaller size of the pale spot situated immediately below the junction of the interspaces formed by the first and third veins. Decumbent hairs moderately numerous and extending almost to the base of the wing.

HYPOPYGIUM (fig. 16). The structure of the hypopygium differs from that of *C. distinctipennis* as follows:—*Ninth segment*: posterior margin of the tergite less deeply notched in the middle line, and the lateral finger-like extensions relatively shorter. *Harpes* (fig. 20 *k*) with the distal portion longer and narrower, and the apical third bent sharply in a ventral direction. *Aedoeagus* tapering more gradually, the arch formed by the limbs being distinctly more pointed, and the ventral wall prolonged anteriorly for a greater distance. The membrane connecting the aedoeagus

with the ninth sternite clothed with spicules on its anterior two-thirds.

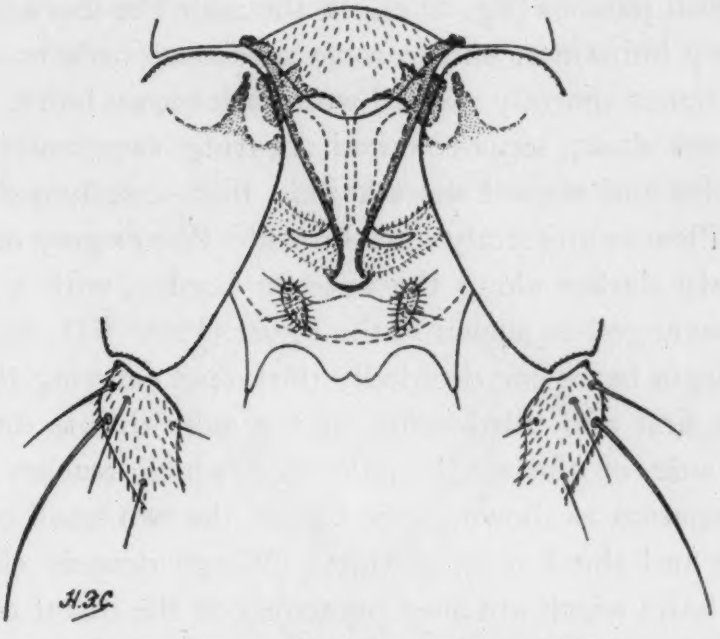

FIG. 16. *C. praetermissus*, sp.n., male hypopygium, ventral view. (× 400.)

HABITAT: Accra, Gold Coast. Collected in the evening upon a window in the laboratory.

Culicoides accraensis, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·2 mm.	1·1 mm.
Length of wing	1·1 mm.	1·0 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

Head, occiput dark brown, clothed with short, dark, hairs; clypeus and proboscis dark brown, hairy. Eyes separate in both sexes; internal chitinous thickening in female well-developed. Palpi (fig. 3 *c*) dark brown; third segment very strongly inflated, fourth segment small, shorter than the fifth. *Antennae*: torus brown, flagellum segments paler; antennal segments four to ten in the female from about one and one-third to twice as long as broad; plumes of the male greyish, the last three antennal segments sub-equal, the thirteenth segment slightly the longest. *Thorax* dark brown, with two broad, admedian, dusky-white stripes which

Culicoides praetermissus, sp. n.

This species is very closely allied to *C. distinctipennis*, Aust., and is described from a single male which had been preserved in alcohol together with several examples of *C. distinctipennis.* In due course an examination of the hypopygium of this specimen revealed its distinctiveness, and although we are unable to give any details of the ornamentation of the thorax, the wing markings remained visible and showed slight differences which will probably enable both sexes of the species to be identified without great difficulty.

MEASUREMENTS.

Length of body	1·0 mm.
Length of wing	0·75mm.
Greatest breadth of wing	0·3 mm.

Eyes separate, much as in *C. distinctipennis.* Thirteenth and fifteenth antennal segments sub-equal. Scutellum bearing two central and two lateral bristles, and two short hairs immediately above the central pair of bristles. Wing venation and markings as shown in Plate VII, fig. 3. The markings are very similar to those of *C. distinctipennis* but differ chiefly in the presence of an additional small, pale, spot situated just beyond and below the conspicuous spot at the end of the costa, and apparently in the smaller size of the pale spot situated immediately below the junction of the interspaces formed by the first and third veins. Decumbent hairs moderately numerous and extending almost to the base of the wing.

HYPOPYGIUM (fig. 16). The structure of the hypopygium differs from that of *C. distinctipennis* as follows:—*Ninth segment*: posterior margin of the tergite less deeply notched in the middle line, and the lateral finger-like extensions relatively shorter. *Harpes* (fig. 20 *k*) with the distal portion longer and narrower, and the apical third bent sharply in a ventral direction. *Aedoeagus* tapering more gradually, the arch formed by the limbs being distinctly more pointed, and the ventral wall prolonged anteriorly for a greater distance. The membrane connecting the aedoeagus

with the ninth sternite clothed with spicules on its anterior two-thirds.

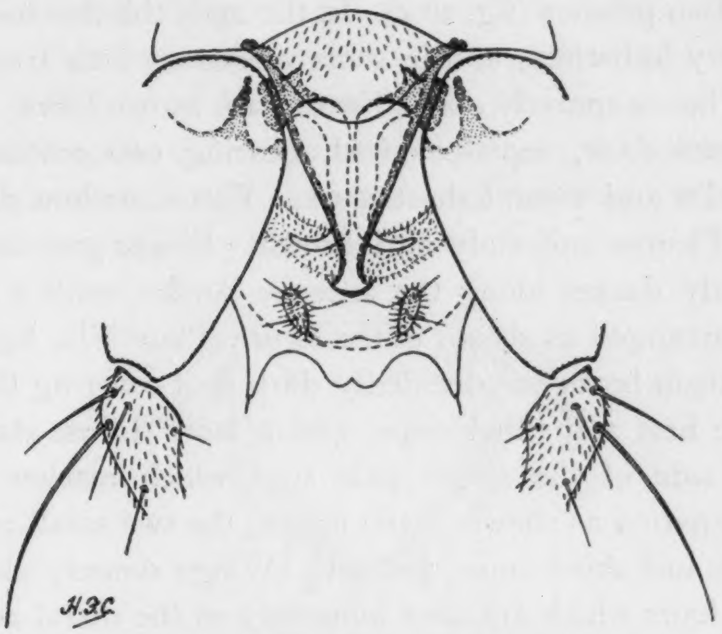

FIG. 16. *C. praetermissus*, sp.n., male hypopygium, ventral view. (× 400.)

HABITAT: Accra, Gold Coast. Collected in the evening upon a window in the laboratory.

Culicoides accraensis, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·2 mm.	1·1 mm.
Length of wing	1·1 mm.	1·0 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

Head, occiput dark brown, clothed with short, dark, hairs; clypeus and proboscis dark brown, hairy. Eyes separate in both sexes; internal chitinous thickening in female well-developed. Palpi (fig. 3 *c*) dark brown; third segment very strongly inflated, fourth segment small, shorter than the fifth. *Antennae*: torus brown, flagellum segments paler; antennal segments four to ten in the female from about one and one-third to twice as long as broad; plumes of the male greyish, the last three antennal segments sub-equal, the thirteenth segment slightly the longest. *Thorax* dark brown, with two broad, admedian, dusky-white stripes which

expand posteriorly to cover the depressed area in front of the scutellum; near the centre of this area are two relatively large rounded black spots and laterally, above the wing roots, are two curved whitish patches (fig. 22 *e*). In the male the thoracic ornamentation is very indistinct, and in some specimens little trace of it can be seen. Thorax sparsely clothed with dark brown hairs. Scutellum in both sexes dark, sepia-coloured, bearing two central and two lateral bristles and several short hairs. Post-scutellum dark, sepia-coloured. Pleurae uniformly dark brown. *Wings* grey or brownish-grey, slightly darker along the anterior border, with a number of pale spots arranged as shown in the figure (Plate VII, fig. 5). The anterior margin bears one decidedly dark spot covering the terminations of the first and third veins, and a more diffuse dark spot on the distal side of the single pale spot which reaches the costal border. Venation as shown in the figure; the two small cells formed by the first and third veins distinct. Wings densely clothed with decumbent hairs which are most numerous on the distal and anterior parts; in the male these hairs are more scanty. *Halteres* brownish-yellow, the distal portion of the stems darker brown. *Legs* brownish, femora and tibiae slightly infuscated, with darker knee-spots which have on the distal (tibial) side on all the legs, and on the proximal (femoral) side on the fore legs, a narrow whitish band. *Abdomen* dark brown, clothed with dark hairs. In freshly emerged specimens there are, on the ventral aspect, three lighter coloured longitudinal stripes, a median and two lateral. Spermathecae usually two in number, but occasionally a very small third one is present; not very highly chitinised, oval, in one instance measuring 42μ by 38μ; a small part of the commencement of the duct is chitinised.

HYPOPYGIUM (fig. 17). *Ninth segment*: sternite with a rather shallow ventral excavation; tergite relatively narrow posteriorly, with well-developed finger-like extensions and apical lobe-like processes, the posterior margin not notched. *Forceps*: side-pieces and claspers normal, similar to those of *C. distinctipennis* (fig. 7). *Harpes* (fig. 20 *a*) large broad structures, branched; the ventral branch in the form of a short rounded knob, the dorsal branch a longer structure, at first directed dorsally, then arching over the ventral branch and ending in a broad, ventrally directed, blade with

five to seven filiform processes on its posterior edge. *Aedoeagus* large, Y-shaped, very highly chitinised; the narrow, distal portion extends backwards as a gutter-like process with the apex bent slightly in a ventral direction; the limbs of the arch, as seen in a ventral view, show incurved proximal extremities and wide lateral thickenings with highly chitinised edges, the inner of which are looped near the apex of the arch and project beyond the outer edges as pointed processes. The membrane connecting the aedoeagus with the ninth sternite is without spicules.

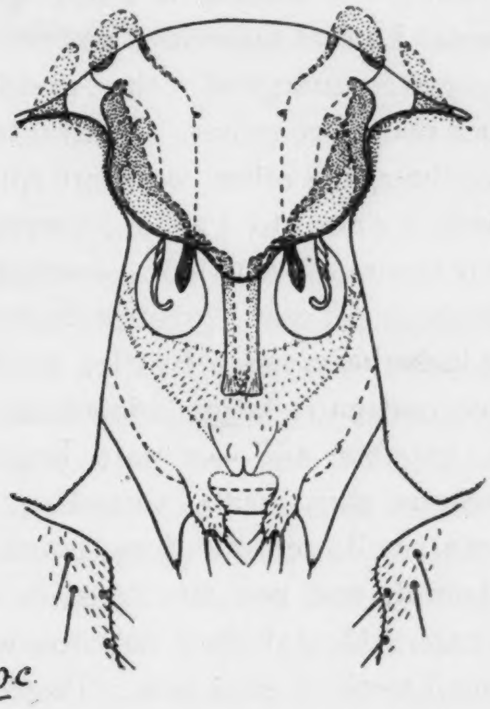

FIG. 17. *C. accraensis*, sp.n., male hypopygium, ventral view. (× 400.)

PUPA. Length 1·6 mm. to 2·4 mm., average of five 2·1 mm. *Respiratory trumpets* as shown in fig. 12. Length about 0·2 mm. The trumpets are narrow in the middle thirds, and slightly dilated at the free ends; they bear two to four blunt knobs. The main tracheal trunk terminates distally in a fan-like arrangement of about six short, blunt, processes. *Cephalo-thorax.* Anterior marginal tubercle, large, conical, bearing a long stout bristle or spine; anterior dorsal, large, conical, bearing a long bristle and a short spine; dorso-lateral, bearing one long and one or two short bristles; ventro-lateral, irregularly shaped, bearing one long and one or two short bristles; ventro-median, very small, bearing a

long and a short hair. Dorsal tubercles: anterior, double, each half bearing a short stout spine; posterior, large and flat, bearing a very short, stout, spine; lateral, bearing a long and a short hair. Other dorsal tubercles, apparently variable, may also be present and are sometimes armed with very minute spines. Postero-dorsal tubercle, small, bearing a single long hair. *Abdomen*: anal segment with pointed processes nearly half as long as the segment. Dorsal tubercles: antero-submarginal, the inner bearing a short spine and the outer a long hair; postero-marginal, the outermost bearing a long hair, the second a small spine, and the inner three minute spines. Lateral tubercles: antero-submarginal, bearing a short spine; postero-marginal, the middle one bearing a long hair, the other two short spines. Ventral tubercles: the middle one bearing a long hair, the other two short spines.

LARVA. Length 2·4 mm. to 3·2 mm., average of seven 2·8 mm. Greatest breadth 0·12 mm. to 0·18 mm., average 0·14 mm.

Head, length about 0·1 mm., greatest breadth 0·08 mm. Eyes small, bilobed or kidney-shaped. Bristles as shown in fig. 10; on the ventral surface one pair, large, admedian, central, two pairs, small, admedian, anterior, and one pair, large, ventro-lateral; on the dorsal surface one pair, small, admedian, anterior, two pairs (one large and one small) central, dorso-lateral, two pairs, small, posterior, dorso-lateral, and two minute pairs admedian, posterior (see footnote, p. 224). Mental plate delicate, with a large terminal tooth and three small teeth on each side. Posterior margin of hypopharyngeal sclerite bearing, on each side, two or three small, one large, and four to six small teeth or processes (fig. 21 *a*). Mandibles simple, pointed, without teeth. *Body*: some of the body bristles are relatively large. Anal segment bearing at its posterior end six pairs of rather long and strong bristles, arranged in two groups of three bristles on each side.

HABITAT: Accra, Nsawam, Odorkor, and Oblogo, Gold Coast. Reared from larvae found in rot-holes in flamboyant trees (*Poinciana regia*), cotton trees (*Eriodendron anfractuosum*), cashew trees (*Anacardium occidentale*), *Cynometra* sp. (probably *C. megalophylla*) and other trees; a few also collected in the evening on the windows of the laboratory at Accra. December, 1919, to April, 1920.

Culicoides neavei, Aust.

Culicoides neavei, Aust. Bull. Ent. Res., Vol. III, p. 102, 1912.

A considerable number of specimens of this species, females of which have previously been recorded from Uganda and the Anglo-Egyptian Sudan, were collected. These specimens have been compared with, and found to be similar to, examples of *C. neavei* kindly sent to one of us by Mr. H. H. King from M'Volo, Anglo-Egyptian Sudan, from which locality examples are referred to by Austen in his original description. Additional characters, including the more important differential points of the male, are given.

Measurements.	Female.	Male.
Length of body	1·3 mm.	1·3 mm.
Length of wing	1·1 mm.	1·0 mm.
Greatest breadth of wing	0·4 mm.	0·35 mm.

The eyes are separate as in *C. distinctipennis*, Aust.; in the female with little indication of the internal transverse thickening. The third segment of the palp is moderately inflated. In the female the fourth to the tenth antennal segments are sub-spherical to oval, the length varying from nearly one and a half to almost twice the width; in the male the thirteen and fifteenth segments are of almost equal length. Scutellum (fig. 5 *c*) with two central and two lateral bristles and a few short hairs. We are unable to agree with Austen regarding the differences in venation between *C. neavei* and *C. distinctipennis*, when he states that in the former species the anterior cross-vein is more oblique, the bifurcation of the fourth vein nearer the base of the wing, and the shape of the interspace between the distal portions of the first and third veins different. Spermathecae two, dark coloured, moderately highly chitinised; nearly spherical, the diameter about 45μ; duct narrow, chitinised for only a short distance, about 4μ, from its commencement.

Hypopygium (fig. 18). *Ninth segment*: the ventral depression in the sternite is deep, semicircular; the tergite of about the usual size, the apical lobe-like processes prominent, the posterior margin with well-developed finger-like processes and very slightly notched centrally with a line running from the notch in an anterior direction to about the middle. *Forceps*: side-pieces normal, claspers bluntly rounded distally, the hairs at the tip being rather

longer than usual. *Harpes* (fig. 20 *i*) in the form of two long, narrow, unbranched chitinous processes; the distal portions each with an almost straight, posteriorly directed basal part, and a slightly spiral apical part which tapers to a filiform end and bears a few minute hairs; the proximal portions highly chitinised, laterally directed, structures articulating with the distal portions of the harpes and the roots of the side-pieces. *Aedoeagus* with the distal portion short and stout, gutter-like, not very highly chitinised, ending abruptly and with a small ventral lip; the

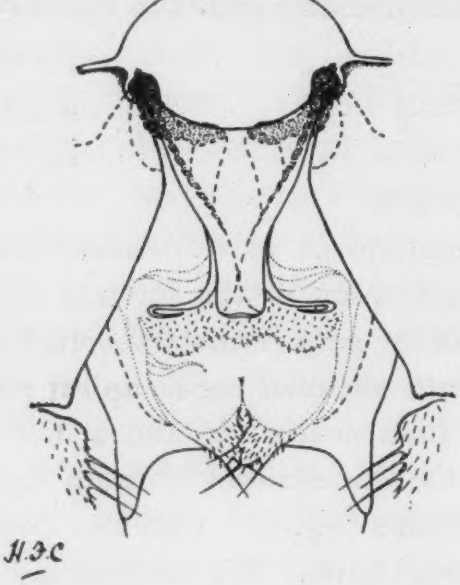

FIG. 18. *C. neavei*, Aust., male hypopygium, ventral view. (× 400.)

proximal portion more highly chitinised, with the basal extremities everted; the arch formed by the limbs is broad and pointed. The ventral wall is chitinised and the membrane connecting it with the ninth abdominal segment is devoid of spicules.

HABITAT: Accra, Gold Coast. Collected in the evening upon the windows of the laboratory, January to April, 1920.

Culicoides clarkei, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·1 mm.	1·2 mm.
Length of wing	1·0 mm.	1·0 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

Head dark brown, occiput dark brown with dark hairs. Eyes narrowly separate, internal chitinous thickening distinct.

Proboscis brown. Palpi brown, the third segment moderately swollen. *Antennae* brown, torus dark brown, flagellum segments paler brown. In the female, the basal segments (four to ten) of the flagellum vary from a little over once to twice as long as broad, the first three or four being broadly oval or sub-spherical; in the male, the thirteenth segment is distinctly longer than the fifteenth. *Thorax* brown, with somewhat indistinct paler brown markings as shown in fig. 22 *a*. Dorsum sparsely clothed with dark brown hairs, which are longest posteriorly. Scutellum dark brown centrally, paler brown laterally; bearing two admedian and two lateral bristles and a few short hairs. Post-scutellum dark brown. Pleurae dark brown. *Wings* grey, with pale coloured spots as shown in the figure (Plate VII, fig. 6). The first pale spot near the middle of the anterior border of the wing envelopes the cross-vein and the proximal portion of the first interspace; its continuation from the first vein to the costa is not clearly defined in some specimens. The wings are relatively densely clothed with decumbent hairs. Halteres with cream coloured or yellowish knobs. *Legs* brown, almost uniformly coloured; fore femora with apical pale bands, middle and hind femora without distinct pale bands; tibiae of all the legs with a rather lighter coloured band upon the bases. *Abdomen* dark brown in dried specimens; scantily clothed with dark hairs which are longest and most numerous on the distal segments. Spermathecae two, dark and highly chitinised; oval or sub-spherical ; the duct chitinised for only a very short distance at its commencement.

Hypopygium (fig. 19). *Ninth segment*: tergite rather broad posteriorly, posterior margin notched in the middle and ending on each side in a well-developed finger-like process. *Forceps* of the usual form. *Harpes* (fig. 20 *e*) simple, long structures, with a sinuous outline, tapering gradually to a thread-like termination, the basal portion with a thickened knob at its proximal end, and forming an obtuse angle at its junction with the terminal portion; the latter is bent ventrally. *Aedoeagus* Y-shaped; stem rather short and slender, not highly chitinised, with a blunt, rounded end; limbs narrow and highly chitinised, in ventral view slightly everted at their bases, forming a rather pointed arch. Ventral wall not chitinised, not differentiated from the membrane joining it to the ninth sternite which is not studded with spines.

PUPA. Length 1·5 mm. to 1·7 mm., average of three 1·6 mm. *Respiratory trumpets* similar to those of *C. accraensis*. Length about 0·17 mm. The trumpets bear two or three blunt knobs. *Cephalo-thorax*: spines on operculum less numerous posteriorly. Tubercles similar to those of *C. accraensis*. Anterior marginal tubercle bearing a long bristle; anterior dorsal, bearing a long hair and minute spine; dorso-lateral, bearing a long and a short hair; ventro-lateral, bearing a long and a rather shorter hair; ventro-median, very small, bearing a minute hair. Dorsal tubercles: anterior single, bearing a short, stout, hair or a long, pointed spine; posterior, bearing a long hair; lateral, bearing a long hair

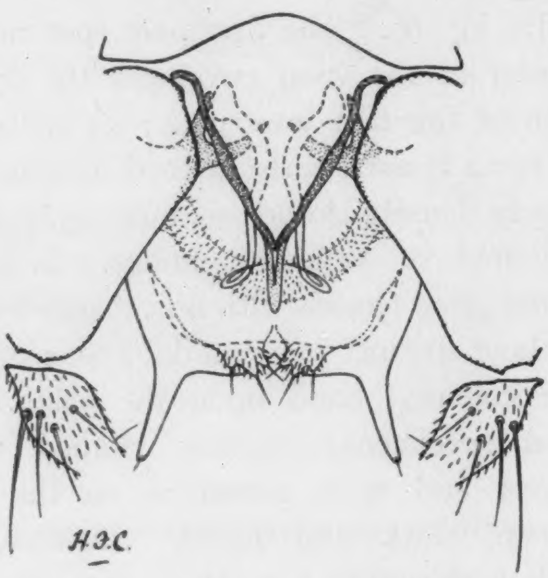

FIG. 19. *C. clarkei*, sp.n., male hypopygium, ventral view. (× 400.)

Of subsidiary dorsal tubercles, mention need be made of one only—this is situated just below the posterior tubercle and slightly nearer the middle line, it is inconspicuous and bears a minute spine. Postero-dorsal tubercle small, bearing a long hair. *Abdomen*: anal segment as in *C. accraensis*; squamose spines on the dorsal surface not very dense, especially posteriorly. Dorsal tubercles: antero-submarginal, each bearing a longish hair; postero-marginal, the outermost bearing a hair, the second a long stout spine, and the inner three minute spines. Lateral tubercles very large: antero-submarginal bearing a long, strong, spine; postero-marginal, the middle one bearing a delicate seta, the other two long, strong, spines. Ventral tubercles: the middle one bears a hair, the other two rather long spines.

LARVA. Length about 3·4 mm., greatest breadth about 0·15 mm. *Head*, length about 0·1 mm., greatest breadth about 0·08 mm., anterior end rather blunt. Eyes rather large, bilobed or reniform. Bristles as in *C. accraensis* but rather smaller. Mental plate somewhat similar to that of *C. accraensis*, with a terminal tooth, and four teeth on each side. Hypopharyngeal sclerite (fig. 21 *d*) large, moderately strongly chitinised, with four teeth on each side posteriorly. Labrum with two of the papillae very long. Mandibles with a small sub-central tooth. *Body*: bristles conspicuous, as in *C. accraensis.*

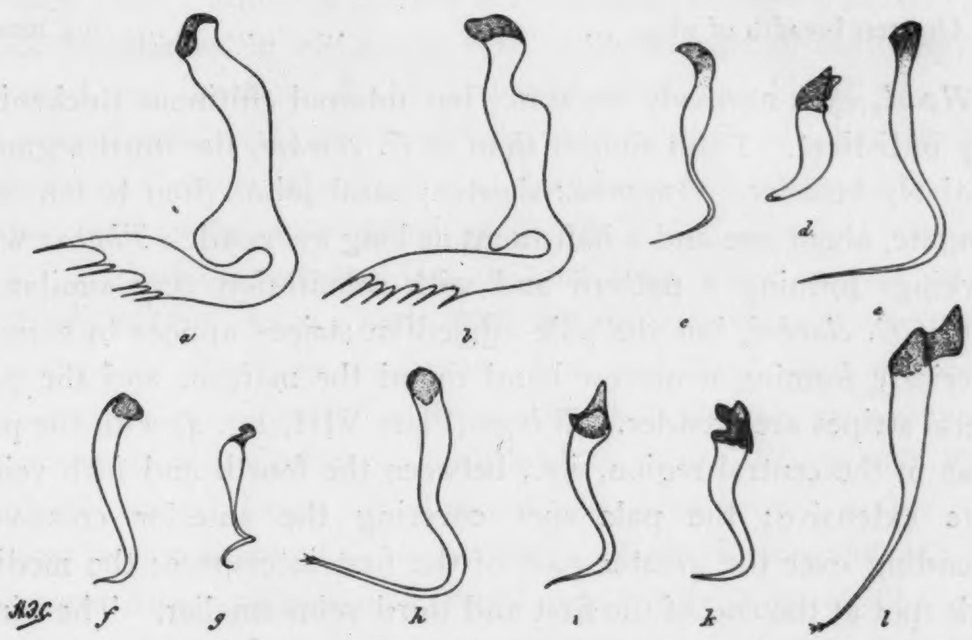

FIG. 20. Lateral views (the distal extremities directed ventrally) of harpes of :— *a*—*C. accraensis*, sp.n.; *b*—*C. similis*, sp.n.; *c*—*C. citroneus*, sp.n.; *d*—*C. distinctipennis*, Aust.; *e*—*C. clarkei*, sp.n.; *f*—*C. punctithorax*, sp.n.; *g*—*C. inornatipennis*, sp.n.; *h*—*C. schultzei* (End); *i*—*C. neavei*, Aust.; *k*—*C. praetermissus*, sp.n.; *l*—*C. austeni*, sp. n. (× 365.)

HABITAT: Accra, Gold Coast; collected in the evening upon the windows of the laboratory. Nsawam and Oblogo, Gold Coast, reared from materials obtained from rot-holes in the stump of a silk-cotton tree (*Eriodendron anfractuosum*), *Cynometra* sp. (probably *C. megalophylla*), and in another tree. December, 1919, to April, 1920.

We have pleasure in dedicating this species to Dr. P. S. Selwyn-Clarke, to whom we are indebted for much assistance in procuring material for this investigation.

Culicoides confusus, sp. n.

This insect, of which we possess a single female, very greatly resembles *C. clarkei*, and, indeed, was originally included among some examples of that species in our collections on account of its almost identical colour markings. Subsequently certain morphological differences were observed which, we think, warrant its separation as a distinct species. Only the chief differences between this species and *C. clarkei* are here given.

MEASUREMENTS.

Length of body	1·1 mm.
Length of wing	0·9 mm.
Greatest breadth of wing	0·4 mm.

Head, eyes narrowly separate, but internal chitinous thickening very indistinct. Palpi shorter than in *C. clarkei*, the third segment relatively broader. *Antennae* shorter; basal joints (four to ten) less elongate, about one and a half times as long as broad. *Thorax* with markings forming a pattern and with colouration very similar to that of *C. clarkei*, but the pale admedian stripes appear to expand anteriorly forming a narrow band round the margin, and the pale lateral stripes are broader. *Wings* (Plate VIII, fig. 4) with the pale areas in the central region, *i.e.*, between the fourth and fifth veins, more extensive; the pale spot covering the anterior cross-vein extending over the greater part of the first interspace; the median dark spot at the end of the first and third veins smaller. The wings are much less densely clothed with hairs, especially at the base between the fourth and fifth veins and posteriorly.

HABITAT: Nsawam, Gold Coast; reared from material obtained from a rot-hole in a silk-cotton tree (*Eriodendron anfractuosum*).

Culicoides eriodendroni, sp. n.

MEASUREMENTS.	Female.
Length of body	1·2 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·4 mm.

Head brown, occiput brown with dark hairs. Eyes very narrowly separate, in some specimens almost meeting in the middle

line; the internal chitinous thickening present. Proboscis brown. Palpi brown; third segment much swollen. *Antennae*: torus dark brown, flagellum segments brown with brown hairs. Seven basal segments (four to ten) of the flagellum elongate, the breadth from one and a half to nearly two and a half times the length. *Thorax* uniformly brown in dried specimens, though traces may be seen of two paler, admedian stripes and lateral markings, which are quite distinct in fresh specimens; clothed with rather long and short brown hairs. Scutellum brown; bearing two central and two lateral bristles and numerous (twelve to fourteen) short hairs. Post-scutellum brown. Pleurae rather lighter in colour than the dorsum. *Wings* grey. Anterior margin bearing only a single pale spot; this spot is situated on the apical side of the middle of the wing, just beyond the junction of the first and third veins with the costa. A second pale, oval, spot covers the anterior cross-vein and the basal portion of the first interspace, but does not reach to the costa. The other pale spots are situated as shown in the figure (Plate VIII, fig. 1); these are always less distinct than those on the anterior portion of the wing, and may be quite indistinct or absent. Venation as shown in the figure: first and third veins infuscated, forming two interspaces; anterior cross-vein oblique, pale coloured; fourth vein forking before the middle of the wing. Wings well clothed with decumbent hairs. Halteres, knobs dark brown, stalks paler, almost cream-coloured. *Legs* brown, dark knee-spots not conspicuous; tibiae with narrow, basal pale bands; tarsi of all the legs lighter in colour than the femora and tibiae. *Abdomen* dark brown in dried specimens. Spermathecae two, oval, unequal (in one specimen measuring 44μ by 39μ and 37μ by 30μ respectively), not very highly chitinised; duct chitinised only at its origin.

PUPA. Apparently almost indistinguishable from the pupa of *C. clarkei*. Average length of four females 2 mm. *Respiratory trumpets* similar to those of *C. clarkei*. Length about 0·2 mm.; stalks short. The trumpets bear three or four blunt knobs. *Cephalo-thorax*: spines on operculum less numerous posteriorly, as in *C. clarkei*. Anterior marginal tubercle bearing a long, stout, bristle; anterior dorsal, bearing a long hair and a short spine; dorso-lateral, bearing two moderately long hairs; ventro-lateral, bearing a long and a moderately long hair; ventro-

median, minute, bearing a minute hair. Dorsal tubercles: anterior, single, bearing a short, stout, spine; posterior, bearing a moderately long hair; lateral, bearing a long hair. Postero-dorsal tubercle bearing a rather stout, short, bristle. *Abdomen*: anal segment normal. Dorsal tubercles: antero-submarginal, each bearing a hair; postero-marginal, the outermost bearing a hair, the second a long, stout, spine, and the inner three minute spines. Lateral tubercles very large: antero-submarginal, bearing a long, strong, spine; postero-marginal, the middle one bearing a delicate seta, the other two long, strong, spines. Ventral tubercles: the middle one bearing a hair, the other two rather long spines.

LARVA. The larva is similar to that of *C. clarkei*. Length 3·6 mm. to 4·6 mm.; greatest breadth about 0·2 mm.

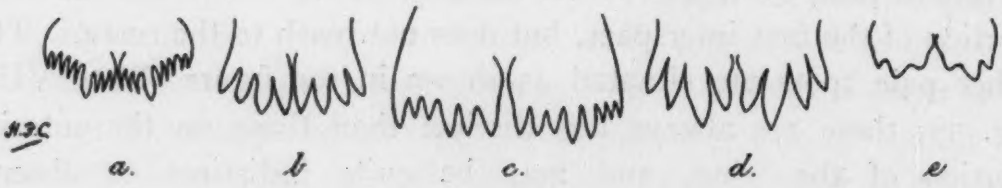

FIG. 21. Posterior margins of hypopharyngeal sclerites of larvae of: *a*—*C. accraensis*, sp.n.; *b*—*C. eriodendroni*, sp.n.; *c*—*C. nigripennis*, sp.n.; *d*—*C. clarkei*, sp.n.; *e*—*C. schultzei* (End.). (× 1050 *circa*.)

Head, length about 0·1 mm., greatest breadth about 0·08 mm. Eyes small, reniform. Bristles arranged similarly to those of *C. accraensis*. Mental plate cone-shaped, bearing four teeth on each side. Hypopharyngeal sclerite (fig. 21 *b*) with four teeth on each side posteriorly. Labrum with long papillae. Mandibles with a small tooth about the apical third. *Body*: bristles rather inconspicuous excepting those at the posterior end of the last segment, which are similar to those of *C. clarkei*.

HABITAT: Nsawam, Dodowah, and Oblogo, Gold Coast. Bred from larvae obtained from rot-holes in the stump of a silk-cotton tree (*Eriodendron anfractuosum*), a mango tree (*Mangifera* sp.), and another tree. All the specimens reared were females. January to March, 1920.

Culicoides nigripennis, sp. n.

Only two adult specimens of this midge, both females, were collected; the measurements of these in a dried condition were as follows:—

MEASUREMENTS.

Length of body	1·2 mm.
Length of wing	1·4 mm.
Greatest breadth of wing	0·5 mm.

Head dark brown. Eyes narrowly separate, with the internal chitinous thickening very indistinct. Proboscis dark brown. Palpi dark brown, third segment moderately inflated in the middle. *Antennae* brown, the torus darker than the flagellum; segments four to ten, oval to sub-cylindrical, one and a half to two times as long as broad. *Thorax* dark brown, becoming dark grey posteriorly, and clothed with dark brown hairs; anteriorly there is an indication of a paler brown, broad, median stripe, and posteriorly, near the centre of the grey area, are two somewhat reniform dark spots. Scutellum dark brown, bearing two central and two lateral bristles and several (twelve) short dark hairs. Post-scutellum dark brown. Pleurae dark brown. *Wings* dark grey, almost uniformly coloured, but the anterior border is somewhat darker than the rest of the wing. Pale spots as shown in the figure (Plate VIII, fig. 2); a small spot covering the anterior cross-vein but not reaching the costa, another small spot upon the anterior margin immediately distal to the point at which the third vein joins the costa, and a slight indication of a light spot at the base of the wing between the first and fifth veins. Venation as shown in the figure. The wing surface is densely clothed with decumbent hairs. Halteres with brown knobs and paler coloured stalks. *Legs* almost uniformly dark brown, but with slight indications of pale, basal, bands on the tibiae; distal tarsal segments somewhat paler than the more proximal segments. *Abdomen* in dried specimens dark brown, with dark brown hairs; in fresh specimens there are minute pale spots, one on each side of the middle line, upon all the abdominal segments. Spermathecae (fig. 6 *c*) two, thinly chitinised, considerably dilated, spherical sacs (diameter 65μ to 70μ) with the commencement of the duct chitinised for a relatively long distance (about 20μ).

PUPA. The following description is based on an examination of two pupal pelts from which females had hatched, and of eight dead pupae (two ♂ and six ♀) found in the material from a rot-hole in a mango tree. Length 2·1 mm. to 2·7 mm., average 2·5 mm. *Respiratory trumpets* rather short and broad; length about 0·2 mm. Stalk or pedicle moderately long. The trumpets are slightly broader at the base and apex than in the middle, and bear two or three very small knob-like processes. The main tracheal trunk terminates distally in a fan-like arrangement of nine short blunt processes. *Cephalo-thorax*: anterior marginal tubercle large, conical, bearing a stout bristle; anterior dorsal, large, conical, bearing a long hair and a very small spine; dorso-lateral large, bearing a long hair and a short spine; ventro-lateral bearing two hairs and, in some specimens, a third minute hair or spine; ventro-median very small, bearing a long, moderately stout hair and a short hair. Dorsal tubercles: anterior, single, bearing a rather long, stout, spine; posterior, bearing a long hair; lateral, bearing a long hair. Behind the posterior tubercle is another tubercle bearing a minute spine, and in front of the anterior tubercle is a rather large, unarmed, tubercle. Postero-dorsal tubercle bearing a long hair. *Abdomen*: anal segment with squamose spines arranged densely almost up to the tips of the processes, which are rather short and, in some specimens, black. Tubercles on the abdominal segments not strongly developed. Dorsal tubercles: antero-submarginal, the inner bearing a short spine and the outer a longer hair; postero-marginal, the outermost bearing a hair, the other four small or minute spines. Lateral tubercles not very large, but better developed than either the dorsal or ventral: antero-submarginal bearing a short spine; postero-marginal, the middle one bearing a hair, the other two short spines. Ventral tubercles: the outer one bearing a short spine, the middle one a hair, and the inner one a minute spine.

LARVA. In a sample of the contents of a rot-hole in a tree sent to us by Dr. F. H. Storey from Adawso, a town about thirty miles north of Accra, two *Culicoides* larvae were found together with a number of mosquito larvae (*Culiciomyia nebulosa*, Theo.). The sample had been sent through the post by a modification of Legendre's (1916) method of transportation, which we have found of considerable

service, and it is interesting to know that *Culicoides* larvae can be transported in this way. The two larvae were isolated separately; the one died, but the other pupated, and from it there emerged on the fourth day a female *C. nigripennis*. The pupal pelt was found floating in the water in the tube, but the larval pelt was not recovered. The following description is made from the larva which died, but which, from its large size, was probably also that of *C. nigripennis*.

Length 4·9 mm., greatest breadth 0·3 mm. *Head*, length 0·23 mm., greatest breadth 0·15 mm. Bristles normal. Mental plate semicircular with a median terminal, and four or five lateral teeth; these are very indistinct and, in the single specimen available, could not be exactly determined. Posterior margin of the hypopharyngeal sclerite as shown in fig. 21 *c*. Palpi with two spines and a short rod at the apex. Antennae as in fig. 10, 4 *a*. *Body*: bristles only moderately developed, the lateral ones relatively smaller than in *C. accraensis*, the arrangement apparently normal. Bristles at the posterior end of the anal segment normal.

HABITAT: Dodowah, Gold Coast: nine pupae found in débris collected from a rot-hole in a mango tree (*Mangifera* sp.), March, 1920; a female emerged from the single living pupa. Adawso, Gold Coast: one female reared from material obtained from a rot-hole in a tree, and sent to us by Dr. F. H. Storey; May, 1920.

C. nigripennis is the largest species of *Culicoides* yet obtained in the Gold Coast; its size, dark coloration and densely hairy wings enable it to be identified with ease.

Culicoides similis, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·3 mm.	1·0 mm.
Length of wing	1·1 mm.	0·9 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

Head brown; occiput dark brown with a few dark brown hairs. Eyes separate in both sexes; in the female the internal chitinous thickening is poorly developed. Proboscis brown. Palpi brown; the third segment considerably swollen and containing a large pit. *Antennae*: torus dark brown, flagellum segments brown bearing

brown hairs. In the female the seven basal segments (four to ten) short, sub-spherical to broadly ovoid, very slightly longer than broad; in the male the last three segments sub-equal. *Thorax* dark brown with pale brownish-grey markings as shown in fig. 22 *f*. Dorsum sparsely clothed with brown hairs. Scutellum pale greyish- or yellowish-brown, almost orange-coloured in fresh specimens, with

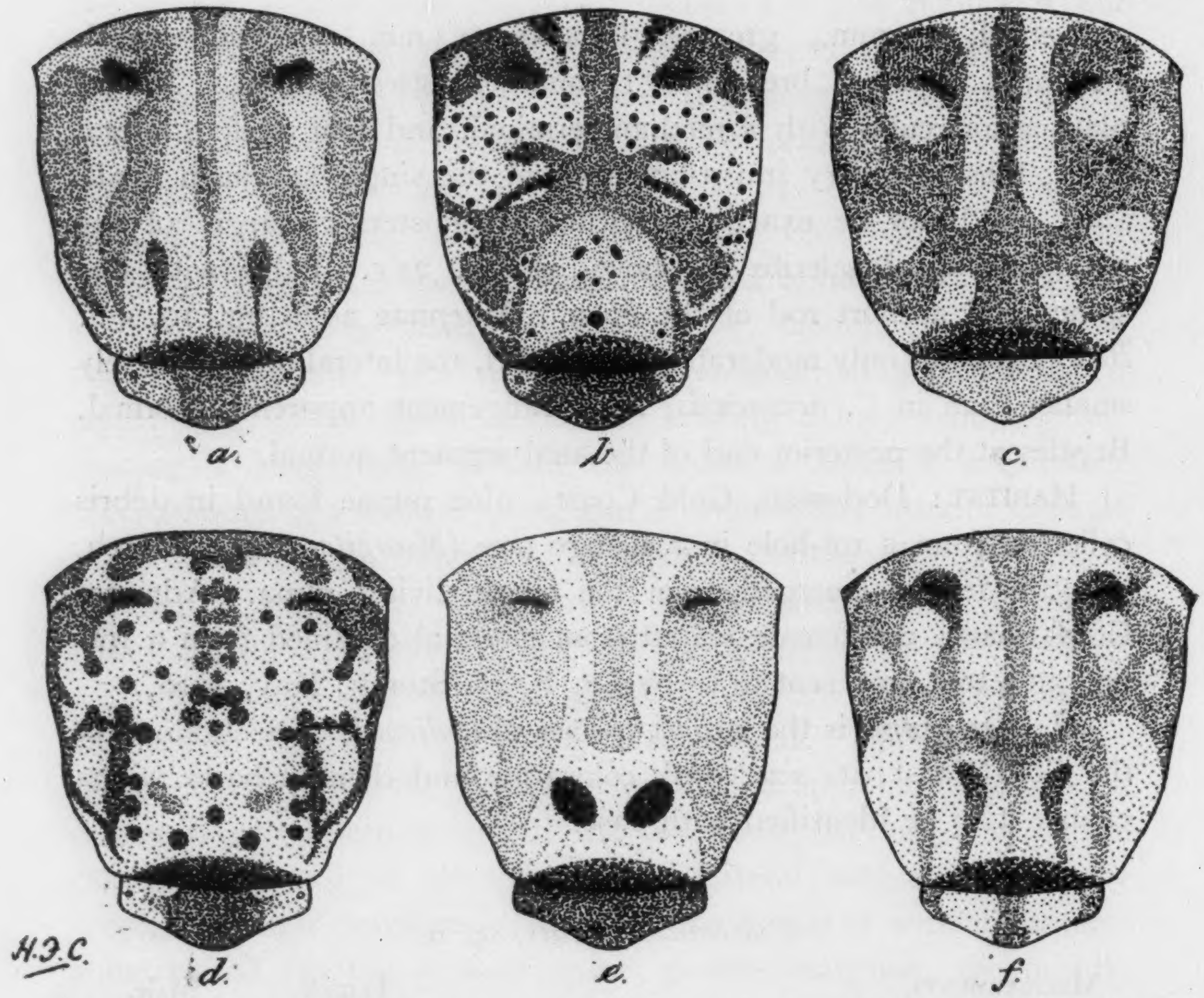

FIG. 22. Thoracic ornamentation of: *a*—*C. clarkei*, sp. n.; *b*—*C. punctithorax*, sp. n.; *c*—*C. inornatipennis*, sp. n.; *d*—*C. schultzei* (End.); *e*—*C. accraensis*, sp. n.; *f*—*C. similis*, sp. n. (semi-diagrammatic.)

a dark median band and dark patches at each side, bearing, in both sexes, two central and two lateral bristles and a few short hairs. Post-scutellum dark brown. Pleurae coloured in a similar manner to the dorsum. *Wings* grey; anterior border rather darker than the rest of the wing and showing successively a light area at the base,

a diffuse dark area, a light-coloured spot covering the basal two-thirds of the proximal interspace and the anterior portion of the cross-vein, a very dark small rectangular spot in the middle of the anterior border at the junction of the first and third veins with the costa, a light coloured spot often divided into two in a more or less transverse direction, a large dark spot less dense than the dark spot at the middle of the anterior margin, and finally a triangular light-coloured spot just before the apex of the wing. These markings and the other pale spots on the wing are shown in the figure (Plate VIII, fig. 6); the three or four pale spots in the neighbourhood of the bifurcation of the fifth vein are of importance in differentiating this species from the following one (*C. citroneus*). Venation as shown in the figure; first and third veins not completely united, but forming two cells; anterior cross-vein oblique, pale at its anterior end; fourth vein forking about the middle of the wing. Wing surface sparsely clothed with decumbent hairs, some of which, however, extend almost to the base of the wing between the fourth and fifth veins. Halteres yellowish, the distal portion of the stem narrowly grey. *Legs* brown, with dark knee-spots; femora with indistinct paler areas near the apex; tibiae with pale basal bands, and some indication of apical pale bands also on the middle and hind legs; tarsal segments rather lighter in colour than the femora and tibiae. *Abdomen* dark brown in dried specimens, clothed with short, dark, hairs. Spermathecae two, not very highly chitinised; ovoid or pyriform (length about 50μ, breadth about 42μ); chitinised portion of the duct long, about 12μ, and slightly tapering.

Hypopygium (fig. 23). *Ninth segment:* sternite with a shallow depression; tergite rather narrow posteriorly, and sparsely clothed with hairs of only moderate length; posterior margin not notched, ending on each side in a rather small finger-like process. *Forceps* of the usual form; side-piece with two sub-dorsal processes at its proximal end, the more posterior of which bears basally a short, blunt, backwardly directed structure. *Harpes* stout, branched appendages closely resembling those of *C. accraensis* (c.f. fig. 20 *a* and *b*); they differ from those of the latter species chiefly in the outline of the inner margin of the proximal portion being more sinuous, so that a more pronounced bulge is present above the middle, and in

the shorter branch being more slender and pointed; the number of serrations on the posterior edge of the blade varies from six to nine. *Aedoeagus*: stem not highly chitinised, very long, and forming (as seen in a lateral view) almost a semicircle with its concave surface ventral; termination filiform. Limbs highly chitinised, narrow, with basal extremities slightly everted; they form a low, broad, arch with a rounded apex. Ventral wall chitinised; membrane between the arch of the aedoeagus and the ninth segment without spines.

HABITAT: Accra, Gold Coast: collected in the evening upon the windows of the laboratory. Oblogo, Gold Coast: reared from material taken from a canoe in the river Densu. January to April, 1920.

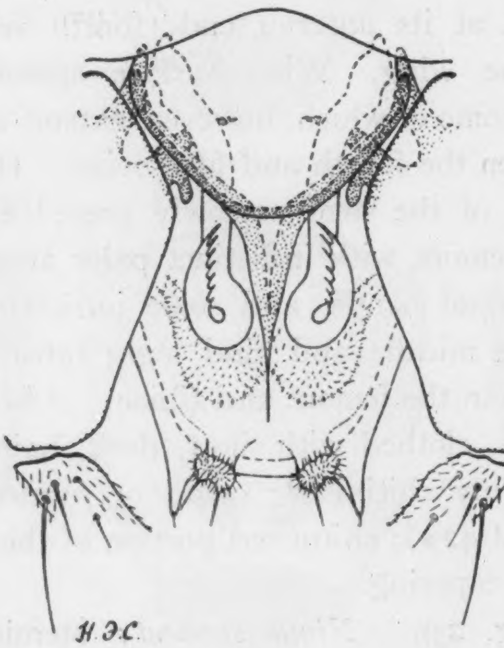

FIG. 23. *C. similis*, sp.n., male hypopygium, ventral view. (× 400.)

The wing markings of this species resemble those of the following species (*C. citroneus*), but the two insects can be distinguished by the arrangement of the pale spots in the neighbourhood of the bifurcation of the fifth vein. The genitalia of the males, however, are quite distinct, the structure of the harpes apparently indicating relationship with *C. accraensis*.

Culicoides citroneus, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·2 mm.	0·8 mm.
Length of wing	1·0 mm.	0·7 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

Head brown, occiput dark brown with dark hairs. Eyes in the female very narrowly separate; internal chitinous thickening distinct. Proboscis and palpi brown, the third segment considerably swollen. *Antennae*: torus brown, flagellum segments lighter brown bearing brownish hairs. Seven basal segments (four to ten) in the female elongate, from nearly two to almost two and a half times as long as broad. In the male the thirteenth segment longer than either the fourteenth or fifteenth. *Thorax*: ornamentation similar to that of the preceding species (*C. similis*), chiefly differing as follows: the pale areas rather darker brown, less distinct; the admedian pale stripes not divided by a transverse dark band near the centre, *i.e.*, the pale areas on the anterior part are continuous with those on the posterior part of the thorax; the large admedian pale spots broadly fused with the admedian stripes; the conspicuous black oval spots on the posterior part not prolonged to the posterior margin by dark stripes. Dorsum sparsely clothed with brown hairs. Scutellum also marked in a similar manner to that of the preceding species, but less distinctly; bearing two central and two lateral bristles, and, in the female, a few short hairs also. Post-scutellum dark brown. Pleurae with colouration similar to that of the dorsum. *Wings* with markings similar to those of the preceding species (*C. similis*), the chief differences being: the pale spot situated near the middle of the anterior border covering the proximal half only of the first cell and completely enveloping the cross-vein (see Plate VIII, fig. 5), and the presence of a small pale area in the angle of the fork of the fifth vein. Venation also differing slightly: the petiole of the cell enclosed by the rami of the fourth vein distinctly longer, and the cell itself less attenuated basally, than in the preceding species. Wings sparsely clothed with decumbent hairs, but with a few (between veins four and five) extending beyond the anterior cross-vein. Halteres with bright lemon-yellow coloured knobs. *Legs* brown; fore legs with con-

spicuous dark knee-spots, above and below which are narrow pale bands; middle legs with pale knee-spots, most marked on the tibial side; hind legs with a conspicuous narrow, pale, band at the base of the tibiae. *Abdomen* dark brown in dried specimens, clothed with short, dark, hairs. Spermathecae two, rounded or oval, moderately well chitinised, diameter about 50μ; practically no part of the commencement of the duct is chitinised.

HYPOPYGIUM (fig. 24). *Ninth segment* of the usual form; posterior margin of the tergite notched in the middle and ending, on each side, in a relatively long, narrow, finger-like process. *Forceps*: side-pieces normal; small hairs extending about two-thirds the length of the claspers. *Harpes* (fig. 20 *c*) simple, tapering to a

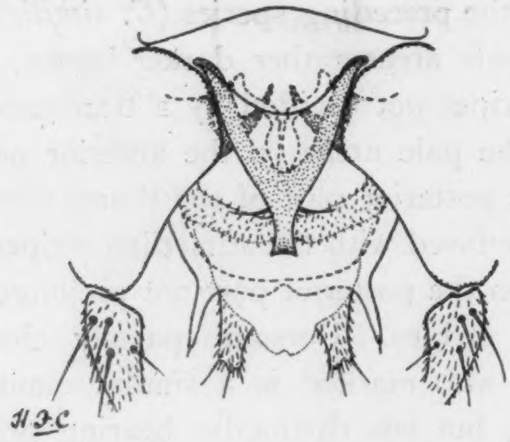

FIG. 24. *C. citroneus*, sp.n., male hypopygium, ventral view. (× 400.)

thread-like termination, root-like basal portion highly chitinised and almost at a right angle to the terminal portion; terminal portion slightly sinuous, attenuated before the middle and with the end bent sharply ventrally. *Aedoeagus* Y-shaped, gradually tapering to a distal, rather broad, gutter-like process with a blunt termination; in ventral view, their extremities apparently turned slightly outwards; the arch formed by the limbs relatively narrow and pointed. Ventral wall chitinised, the membrane connecting it with the ninth sternite not spiculated.

HABITAT: Accra, Gold Coast. Collected in the evening upon the windows of the laboratory from December, 1919, to April, 1920; never abundant, and very uncommon in February.

Culicoides austeni, sp. n.

Culicoides milnei, Aust. (pro parte). Ann. Mag. Nat. Hist. Ser. 8, Vol. III, p. 283, 1909; Bull. Ent. Res., Vol. III, p. 100, 1912.

In 1912, Austen noted that specimens of *C. milnei* from the Anglo-Egyptian Sudan and Southern Nigeria differed from the type form from Nairobi 'in being considerably smaller, and in having the two distal light costal spots on the wings much closer together' and suggested that in these places it was apparently represented by a local race. A careful comparison of the type and paratypes of *C. milnei*, Aust., with the Southern Nigerian (Yaba) specimens preserved in the British Museum collections leads us to believe that the so-called small race of *C. milnei*—which occurs in the Congo and Uganda as well as in British West Africa—is specifically distinct, and we therefore propose for it the name *C. austeni*.

Apart from the distinguishing characters mentioned by Austen, this species differs from the true *C. milnei* in the more distal of the two small cells or interspaces, enclosed by the first and third veins, being distinctly narrower, and in the decumbent wing-hairs extending further towards the base of the wing between the upper branches of the fourth and fifth veins. In *C. austeni* the hairs in this area extend almost to the middle of the wing, whereas in *C. milnei* they reach to about the apical third only. Further, a microscopic preparation of a female received from Nairobi shows that the eyes are distinctly, though narrowly, separate above, while in females of *C. austeni* they are contiguous. This character cannot, as a rule, be accurately determined in dry specimens, and in the type and paratypes could not be satisfactorily observed; but as the Nairobi example in our possession agrees in all other details with the type of *C. milnei* we feel justified in regarding it as Austen's species, and in giving as an additional and important distinguishing feature between females of *C. milnei* and *C. austeni* the separation or contiguity of the eyes.

We have collected at Accra numerous specimens of *Culicoides austeni*, and have been fortunate in obtaining both males and females. The male has been previously collected, and Austen (1912) refers to one taken at Yaba near Lagos. The males collected by us were similar to the females, but of slighter build and with

the eyes narrowly separate. The average measurements of three specimens after immersion in pure carbolic were as follows:—Length of body, 1·2 mm.; length of wing, 1·1 mm.; greatest breadth of wing, 0·3 mm. In the female the eyes are broadly contiguous above; antennal segments four to ten are oval to sub-cylindrical, from one and a half to two and a quarter times as long as broad. Palpi as shown in fig. 3 *a*. Spermathecae (fig. 6 *d*) two in number, dark coloured, highly chitinised, sub-spherical—the diameter about 33μ; the duct narrow, chitinised for a very short distance (about 3μ) only. In both sexes the scutellum bears two central and two lateral bristles and, in the female, additional short hairs.

HYPOPYGIUM (fig. 25). *Ninth segment:* ventral depression in the sternite of moderate depth; tergite of about the usual length,

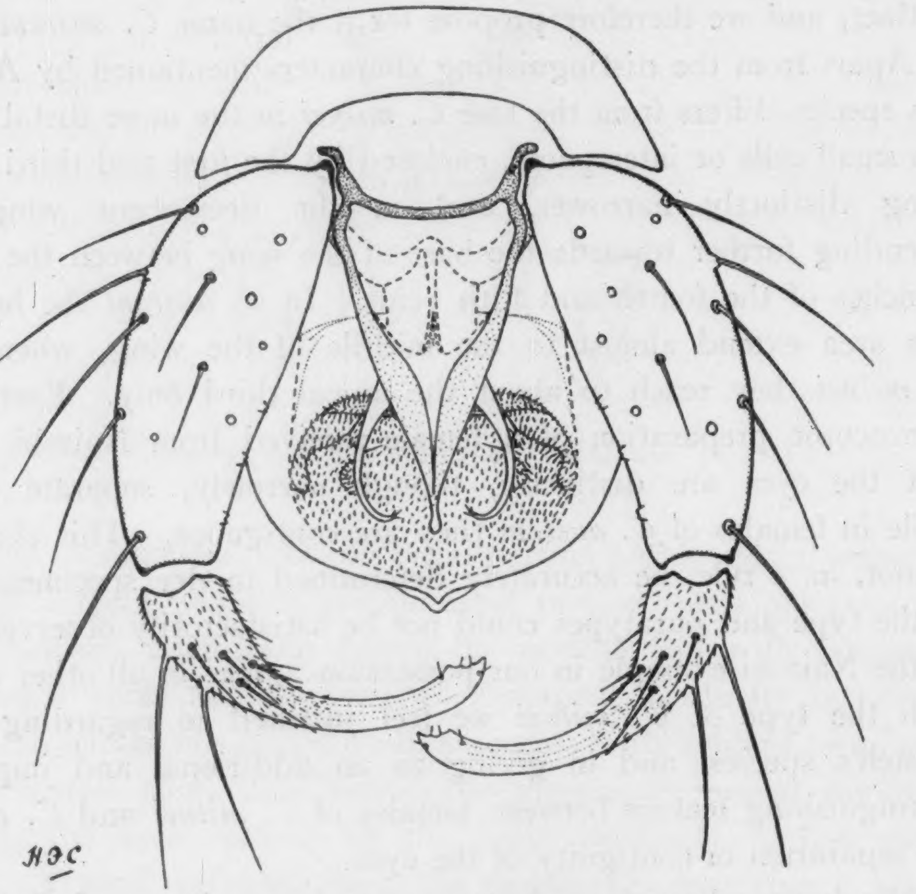

FIG. 25. *C. austeni*, sp.n., male hypopygium, ventral view. (× 400.)

almost as broad posteriorly as at the base, sparsely clothed with strong hairs which are most numerous over the posterior third; posterior margin slightly notched in the middle, with a line extending from the notch for a short distance in an anterior

direction; posterior margin without lateral processes, but with a small triangular projection in the middle behind the notch. *Forceps*: side-pieces highly chitinised and hairy; end of clasper only slightly depressed. *Harpes* (fig. 20 *l*) unbranched; the proximal or basal portion directed laterally, approximately at a right angle to the rest of the appendage, highly chitinised, with the external extremity bent anteriorly; the distal portion long, not very highly chitinised, gradually tapering to a filiform end which bears a few minute hairs; general direction ventral, but considerable twisting, especially distally, occurs. *Aedoeagus* V-shaped rather than Y-shaped, concave ventrally; distal portion long, not very highly chitinised, concave ventrally, and tapering to end in a small knob; limbs more highly chitinised, especially at their bases, forming a somewhat narrow, pointed, arch, the acute apical angle of which is occupied by a small tooth-like projection of the dorsal wall; ventral wall chitinised, limited anteriorly by a highly chitinised transverse band, beyond which the limbs project slightly. The membrane connecting the ventral wall with the abdomen appears to be without spicules.

HABITAT. Accra: collected in the evening upon the windows of the laboratory, January to April, 1920; and one specimen taken in a bungalow in March. Sekondi: one specimen collected by Dr. W. G. Watt, April, 1920.

Culicoides grahami, Aust.

Culcoides grahamii, Aust. Ann. Mag. Nat. Hist., Ser. 8, Vol. III, p. 280, 1909; Illustrations of African Blood-sucking Flies, p. 7, Pl. I, fig. 3, 1909.

Culcoides habereri, Becker. Jahreshefte des Vereins fur vaterland. Naturkunde in Wurttemberg, Jahrg., 1909, p. 289, Taf. VIII, Bd. IX 1909.

? *Oecacta hostilissima*, Pittaluga. Centr. Bakt. Abt. I, Bd. 59. Orig. p. 69, 1911.

Numerous examples of this species were collected both at the Accra laboratory and at Tafo and villages in the Koforidua district, but in spite of its apparent abundance no breeding-places were located.* Males were obtained only on the laboratory windows.

MEASUREMENTS.	Female.	Male.
Length of body	0·9 to 1·2 mm.	1·0 mm.
Length of wing	1·0 mm.	0·9 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

* Since the above was written, larvae of *C. grahami* have been found in rotting material at the bases of banana plants.

The eyes of the female, as described by Becker, are contiguous dorsally for a somewhat variable distance; in the male they are narrowly separate, almost contiguous at the vertex. The third palpal segment is but slightly swollen. The antennae of the female are of moderate length, the basal segments (four to ten) varying from about one and a half to two times as long as broad, the last antennal segment of the male is slightly longer than either of the two preceding segments. The scutellum of the female bears three bristles, one central and two lateral, and is devoid of short hairs; that of the male bears a central bristle only (c.f. fig. 5, *a* and *b*). In our specimens the pale spots on the wings are more numerous than shown in Austen's figure, but the additional ones are ill-defined. The latter are situated along the middle line of the wing, notably at the base, and on each side of the termination of the lower ramus of the fourth vein. The decumbent hairs are not entirely confined to the upper portion of the distal extremity of the wing, and are present, though extremely scanty, along the apical and posterior margins. In the male the hairs are arranged as in the female, but are even less numerous. The spermathecae are dark and highly chitinised, variable in number and size; two or, occasionally, three, are present, and although usually almost spherical in shape (diameter about 40μ) are sometimes oval. The duct is chitinised at its commencement for but a short distance.

Hypopygium (figs. 26 and 27). *Ninth segment:* sternite with the excavation moderately deep; tergite relatively short, the posterior margin notched centrally, without finger-like processes but extended into a short, rounded, flange on each side of the middle line. Apical, lobe-like, processes moderately well-developed. *Forceps*: basal half of clasper covered with minute hairs and bearing also a few relatively strong hairs; distal portion with four or five minute hairs, the apex pointed. *Harpes*: distal portion long, narrow, unbranched, rather strongly curved and bent ventrally at the apex, which is filiform and bears a few minute hairs; proximal portion rather more highly chitinised than the rest of the harpe, directed slightly dorsally. *Aedoeagus* of normal form (Y-shaped) with the distal extremity bent ventrally. The distal portion is rather short and narrow, not very highly chitinised, with a bluntly rounded end; the limbs are more highly chitinised, especially at

their proximal, everted ends, and form a narrow arch over the excavation in the ninth sternite; the apex of the arch is occupied by a chitinised, pointed, spine-like prolongation of the dorsal wall. The ventral wall is distinctly chitinous and the membrane connecting it with the ninth sternite bears a few minute spicules.

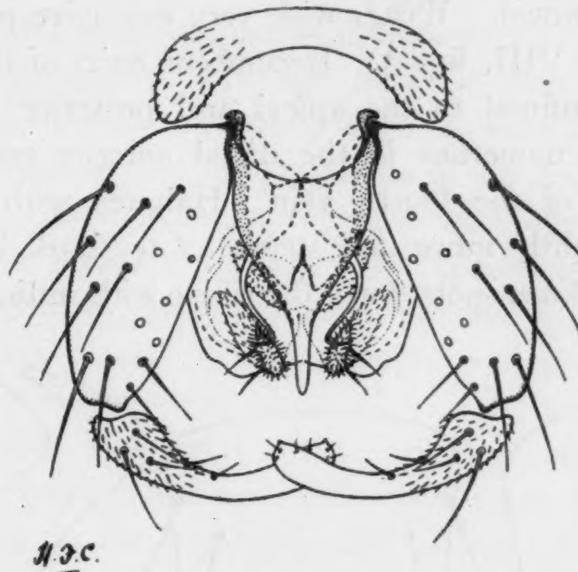

FIG. 26. *C. grahami*, Aust., male hypopygium, ventral view (spicules on anterior portion of membrane, connecting ventral wall of aedoeagus to ninth sternite, omitted). (× 400.)

HABITAT: Accra, Gold Coast, both males and females collected in the evening on the windows of the laboratory from December, 1919, to April, 1920, but very uncommon in February. Females also collected at Tafo, and villages in the Koforidua district by Dr. F. H. Storey.

Culicoides pallidipennis, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·3 mm.	1·1 mm.
Length of wing	1·1 mm.	0·9 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

Head dark brown. Eyes contiguous in the female, narrowly separate in the male. Proboscis and palpi dark brown, the latter with the third segment slender, scarcely at all dilated. *Antennae* brown, the first two segments darker than the rest. Segments four to ten in the female, oval to sub-cylindrical, from once and

a half to twice as long as broad; thirteenth segment in the male, slightly longer than the terminal segment. *Thorax* rather dark greyish-brown, clothed with pale brown hairs; the anterior pit and two elliptical areas near the centre of the posterior depression darker, almost black. Scutellum in both sexes dark greyish-brown, with bristles as in *C. grahami*. Post-scutellum dark brown. Pleurae dark brown. *Wings* with very extensive pale markings as shown in Plate VIII, fig. 3. Decumbent hairs of the wings scanty and almost confined to the apical and posterior marginal areas; they are most numerous in the distal anterior portion above the upper branch of the fourth vein. Halteres with cream-coloured knobs and slightly infuscated stems. *Legs* dark brown, the tarsi slightly paler; knee-spots dark, the tibiae with indications of narrow

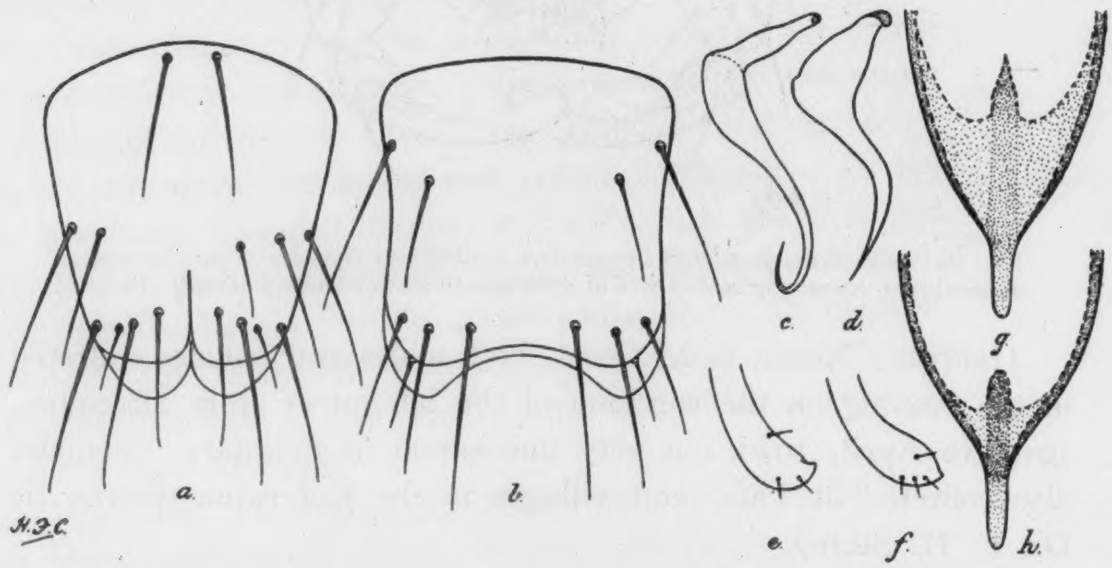

FIG. 27. Hypopygial details of the males of *C. grahami*, Aust. (*a*, *c*, *e* and *g*), and *C. pallidipennis*, sp. n. (*b*, *d*, *f* and *h*) *a* and *b*—ninth tergites; *c* and *d*—harpes; *e* and *f*—extremities of claspers; *g* and *h*—aedoeagus. (*a* and *b* × 360, *c*—*h* × 490.)

pale bands at the base. *Abdomen* dark brown, almost black distally, clothed with dark brown hairs. Spermathecae two, dark and highly chitinised, sub-spherical, about 50μ by 45μ; a very short portion of the duct is chitinised.

HYPOPYGIUM: strikingly similar in structure to that of *C. grahami*. The chief differential points are shown in fig. 27. The ninth tergite is less hairy, relatively broader posteriorly, and not partially cleft in the middle line of the dorsal surface. The distal extremity of the clasper is rather broader and more rounded. The

harpes are shorter and stouter with the basal portions markedly broader. The dorsal wall is less extensive and its spine-like anterior continuation, lying between the limbs of the aedoeagus, is shorter and blunter.

HABITAT: Accra, Gold Coast; collected upon the windows of the laboratory in the evening from December, 1919, to April, 1920, but never abundant, and very uncommon in February.

The close relationship existing between this species and *C. grahami*, Aust., is shown in several ways, notably in the structure of the male hypopygium and the scantiness of the decumbent wing-hairs. The great development of the pale markings of the wings of *C. pallidipennis*, however, will enable the species to be separated with ease. In regard to the last-named character, *C. pallidipennis* resembles *C. brucei*, Aust. The latter species, however, is more robust in build, and possesses sepia-coloured halteres and more numerous decumbent wing-hairs. The wing markings, moreover, are by no means identical, the chief differences being the absence of the small grey spot in the large pale area situated near the tip of the wing above the upper branch of the fourth vein, the more proximal position of the dark transverse band between the branches of the fourth vein, and the absence of the small but sharply defined grey spot in the centre of the cell enclosed by the branches of the fifth vein.

Synoptic Tables

The chief distinguishing characters of the species of *Culicoides* now known to occur in the Gold Coast are summarised in the following tables:—

FEMALES.

1.	Wings, uniformly coloured—without spots ...	*inornatipennis*, sp. n. (p. 227)
	Wings, with distinct pale spots or areas	2
2.	Thorax, entirely ochraceous	*fulvithorax* (Aust.) (p. 230)
	Thorax, grey or brown	3
3.	Thorax, grey or with large grey areas conspicuously spotted dark brown or black	4
	Thorax, almost uniformly coloured or otherwise adorned	5

4. First and third longitudinal veins, separate distally, forming two distinct cells; apical anterior portion of wing with one small pale spot at end of costa ... ... *punctithorax*, sp. n. (p. 235)
First and third longitudinal veins, entirely fused; apical anterior portion of wing with (usually) three or four pale spots, or (if united) with a large semicircular pale area ... *schultzei* (End). (p. 231)

5. Decumbent wing-hairs, dense; numerous in the basal portion of the wing between the fourth and fifth veins (i.e. from the origins of the veins as far as the anterior cross-vein) 6
Decumbent wing-hairs, sparse or scanty; at most a single row of hairs in the basal portion of the wing between the fourth and fifth veins 12

6. Wings, with a pale spot (not connected with the pale spots at the cross-vein and end of costa) immediately below the junction of the two small anterior cells formed by the first and third veins 7
Wings, without such spot 8

7. Wings, with a small circular or oval pale spot just beyond and below the conspicuous spot at the end of the costa; spermatheca single, strongly chitinised, oval ... ... *praetermissus*,* sp. n. (p. 240)
Wings, without such a spot; spermatheca single, very delicately chitinised anteriorly, peg-top shaped ... *distinctipennis*, Aust. (p. 238)

8. Wings, with a small pale spot distally above the end of the upper branch of the fourth vein, and with distinct spots near the distal and posterior margins 9
Wings, without a pale spot distally above upper branch of fourth vein; pale spots near distal and posterior margins absent or ill-defined 11

9. Anterior cross-vein and base of proximal interspace, formed by first and third veins, dark—not enveloped by the pale spot ... ... *accraensis*, sp. n. (p. 241)
Anterior cross-vein and base of proximal interspace enveloped by pale spot 10

10. Wings, with four sharply-defined pale spots forming an interrupted transverse band in the apical third, extending from the pale spot at the end of the costa to the pale spot in the distal angle of the fork of the fifth vein ... ... *neavei*, Aust. (p. 245)
Wing spots not forming such a band ... ... *clarkei*, sp. n. (p. 246)

11. Wings, usually with some ill-defined pale spots near distal and posterior margins; spermathecae normal, oval, the duct scarcely, if at all, chitinised; smaller species (wing length 1·1 mm.) ... ... *eriodendroni*, sp. n. (p. 250)
Wings, without any indication of distal or posterior pale spots; spermatheca very large, spherical, the duct chitinised for a relatively long distance; larger species (wing length 1·4 mm.) ... ... *nigripennis*, sp. n. (p. 253)

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* The character of the spermatheca is based on the examination of a female of what appears to be this species sent by Mr. G. A. H. Bedford from Pretoria; the wing markings agree with those of the male from West Africa.

12. Wings, with pale spot at the end of the costa covering at most the extreme tip of the costa and third vein 13
Wings, with pale spot or area covering at least one third of the distal interspace between the first and third veins 15
13. Fork of fifth vein, with two pale spots—one small, situated immediately below the point of bifurcation ... ... *citroneus*, sp. n. (p. 259)
Fork of fifth vein, with one large pale spot 14
14. Decumbent wing-hairs sparse, but between the fourth and fifth veins reaching as far as the cross-vein and sometimes continued beyond it as a single row ; a clearly defined pale spot immediately above the bifurcation of the fifth vein ... *similis*, sp. n. (p. 255)
Decumbent wing-hairs scanty, not reaching beyond the middle of the wing between the fourth and fifth veins ; no pale spot above the bifurcation of the fifth vein ... *confusus*, sp. n. (p. 250)
15. Decumbent wing-hairs sparse, those between the branches of the fourth vein reaching to about the middle of the wing ... ... *austeni*, sp. n. (p. 261)
Decumbent wing-hairs, below the upper branch of the fourth vein extremely scanty, almost confined to the margins 16
16. Wings, appearing pale with dark areas ... *pallidipennis*, sp. n. (p. 265)
Wings, appearing dark with pale spots ... *grahami*, Aust. (p. 263)

The characters given in the above table will, for the most part, apply to the males also. In one important respect, however, namely, the density of the decumbent wing-hairs, the males differ considerably from the females; these hairs are always less numerous in the males, and although their density varies in different species, the differences are much less easily appreciated than in the females. A table of the males based on the characters of the hypopygium is, therefore, appended.

MALES.

1. Posterior margin of ninth tergite, with conspicuous lateral finger-like processes 2
Posterior margin of ninth tergite, without finger-like processes ... 11
2. Membrane, connecting ventral wall of aedoeagus with ninth tergite studded with spicules 3
Membrane, connecting ventral wall with tergite devoid of spicules 5
3. Distal portion of aedoeagus straight, broad and gutter-like ; harpes long and tapering, sharply bent near the middle ... ... *schultzei* (End.) (p. 231)
Distal portion of aedoeagus narrow, expanding into a mushroom-like apex ; harpes short with the tips only bent 4
4. Extreme apex of harpes only bent ; membrane connecting ventral wall of aedoeagus with ninth sternite completely studded with spicules ... ... *distinctipennis*, Aust. (p. 238)
Apical third of harpes bent ; membrane spiculated on anterior two-thirds only ... ... *praetermissus*, sp. n. (p. 240)

5. Harpes, large and broad, with serrated blade-like distal portions ... 6
Harpes, tapering to a pointed apex, the distal portion usually filiform 7

6. Distal portion of aedoeagus straight, broad, and gutter-like ...
... ... *accraensis*, sp. n. (p. 241)
Distal portion of aedoeagus tapering, the apical third filiform ...
... ... *similis*, sp. n. (p. 255)

7. Finger-like processes of ninth tergite, 8-9 times as long as the width in the middle ... ... *punctithorax*, sp. n. (p. 235)
Finger-like processes of ninth tergite, at most 7 times the width in the middle (except in *C. inornatipennis* not more than 6×1) ... 8

8. Distal portion of aedoeagus, slender, slightly tapering; ventral wall not at all or very delicately chitinised, appearing continuous with the membrane connecting it with the ninth sternite ...
... ... *clerkei*, sp. n. (p. 246)
Distal portion of aedoeagus, stout and blunt; ventral wall distinctly chitinised, the line of demarcation between it and the connecting membrane conspicuous 9

9. Finger-like processes of ninth tergite, short and stout (about 3×1)
... ... *neavei*, Aust. (p. 245)
Finger-like processes, $6\text{-}7 \times 1$ 10

10. Filiform distal extremity of harpes with a single sharp ventral bend near the middle ... ... *citroneus*, sp. n. (p. 259)
Filiform distal extremity of harpes twisted ventrally, corkscrew-like
... ... *inornatipennis*, sp. n.. (p. 227)

11. Posterior margin of ninth tergite, with a triangular projection in the middle; ventral wall of aedoeagus bounded anteriorly by a strong chitinous transverse bar ... ... *austeni*, sp. n. (p. 261)
Posterior margin of ninth tergite, without a central projection, but with broadly rounded flanges on each side of the middle line: ventral wall of aedoeagus without chitinous bar 12

12. Ninth tergite, tapering posteriorly and partially cleft in the middle dorsal line ... ... *grahami*, Aust. (p. 263)
Ninth tergite, almost rectangular, without a dorsal cleft ... ...
... ... *pallidipennis*, sp. n. (p. 265)

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Legendre, J. (1916). Sur un nouveau Mode de Transport des Larves de Moustiques. *C. R. Soc. Biol.*, Paris. Vol. LXXXIX, pp. 26-27.

EXPLANATION OF PLATES

Plate VI

Fig. 1. C. [illegible], sp. nov., female wing.

Fig. 2. C. [illegible] Banks, female wing, [illegible] portion of [illegible] [illegible] [illegible]

Fig. 3. C. [illegible], sp. nov., male wing.

Fig. 4. C. [illegible], sp. nov., female wing.

Fig. 5. C. [illegible], sp. nov., female wing.

Fig. 6. C. [illegible], sp. nov., female wing.

NOTE.—The magnification of all the figures is [illegible] [illegible]

EXPLANATION OF PLATES

PLATE VII

Fig. 1. *C. inornatipennis*, sp. nov., female wing.

Fig. 2. *C. schultzei* (End.), female wing; (*a*) portion of anterior proximal area of male wing.

Fig. 3. *C. praetermissus*, sp. nov., male wing.

Fig. 4. *C. punctithorax*, sp. nov., female wing.

Fig. 5. *C. accraensis*, sp. nov., female wing.

Fig. 6. *C. clarkei*, sp. nov., female wing.

NOTE.—The magnification in all the figures is approximately × 90.

PLATE VII

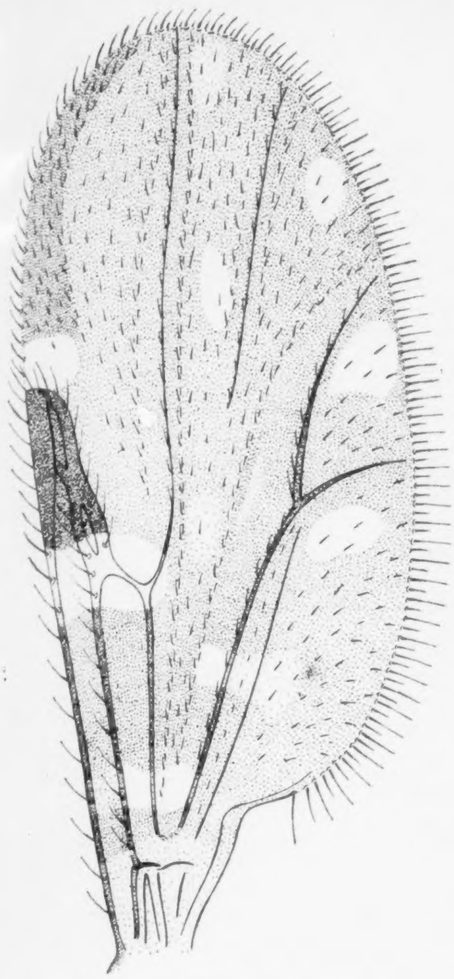

FIG. 4

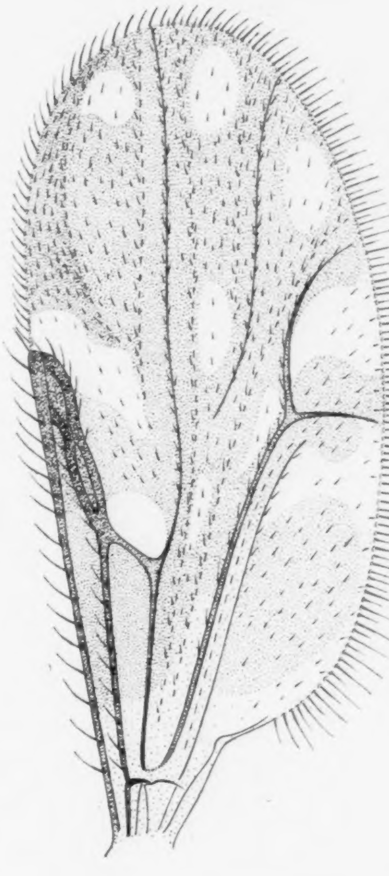

FIG. 5

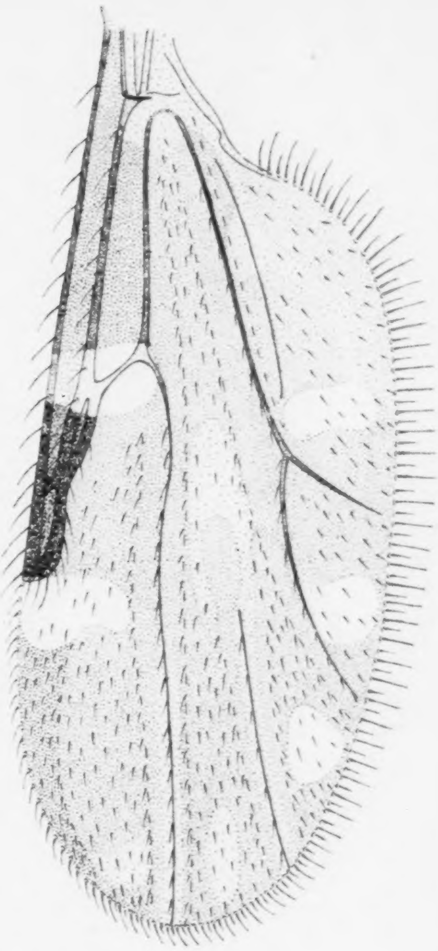

FIG. 6

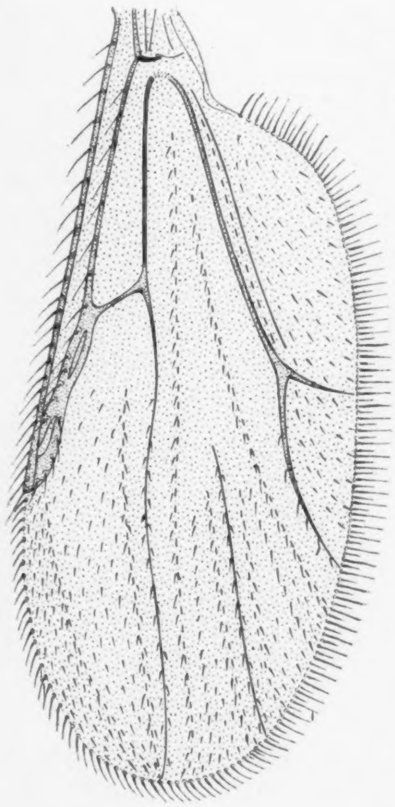

FIG. 1

a

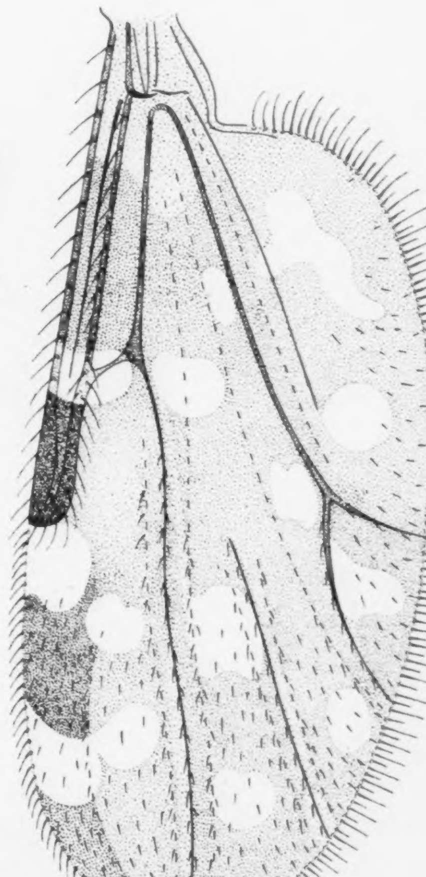

FIG. 2

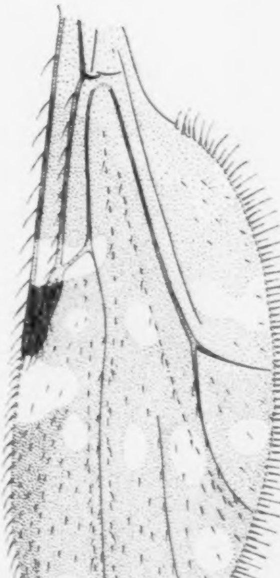

FIG. 3

H. F. Carter, ad nat. del.

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PLATE VIII

Fig. 1. *C. eriodendroni*, sp. nov., female wing.

Fig. 2. *C. nigripennis*, sp. nov., female wing.

Fig. 3. *C. pallidipennis*, sp. nov., female wing (small specimen)

Fig. 4. *C. confusus*, sp. nov., female wing.

Fig. 5. *C. citroneus*, sp. nov., female wing.

Fig. 6. *C. similis*, sp. nov., female wing.

NOTE.—The magnification in all the figures is approximately × 90.

PLATE VIII

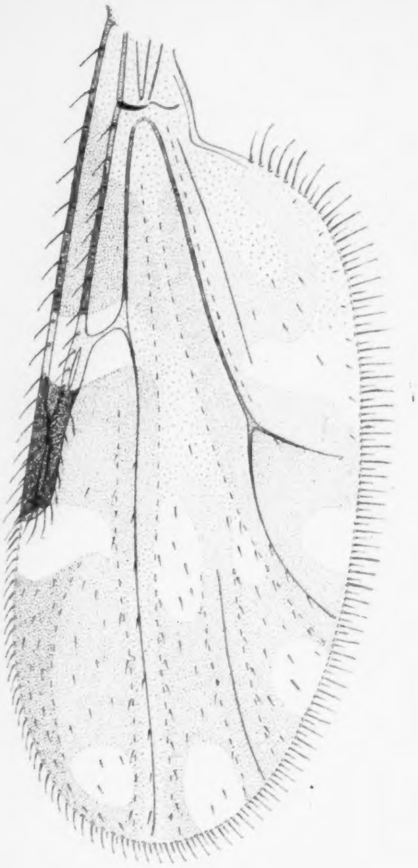

FIG. 4

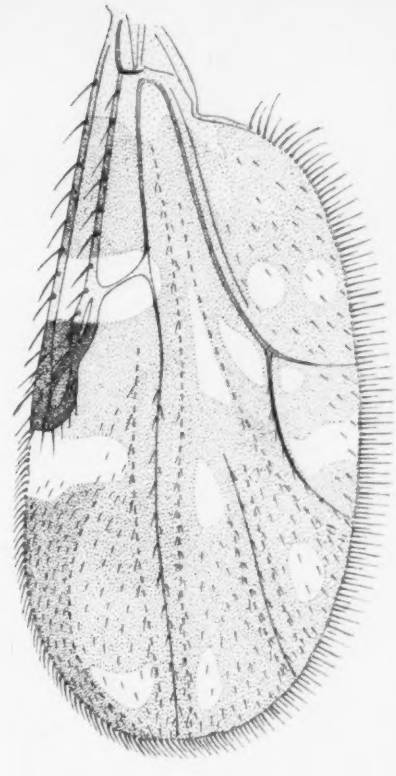

FIG. 5

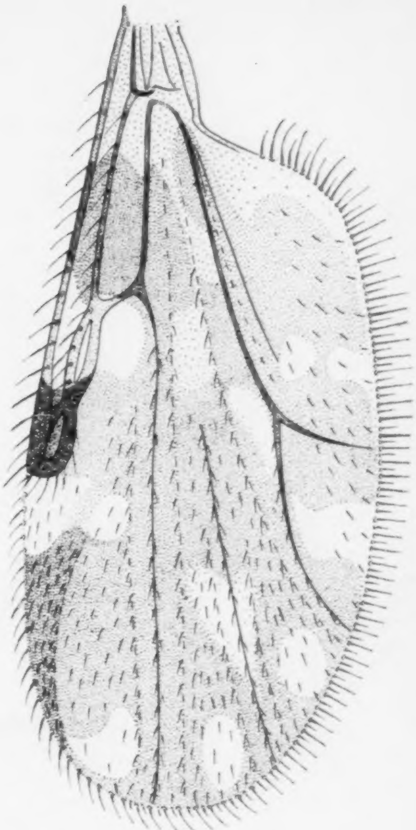

FIG. 6

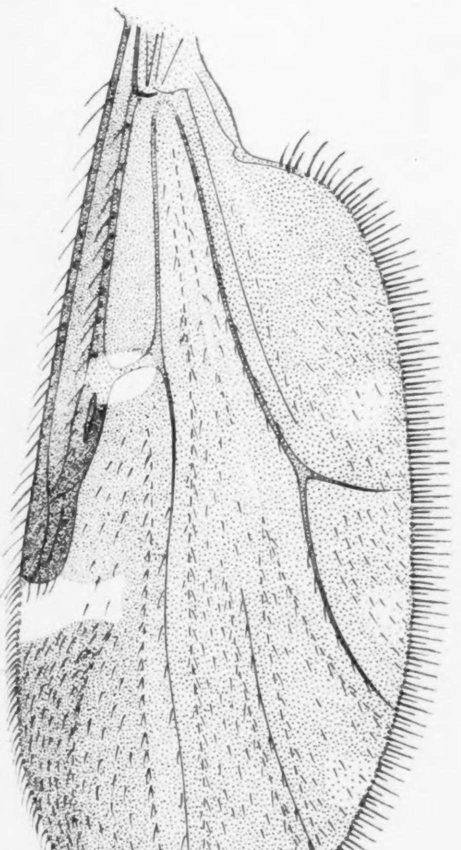

FIG. 1

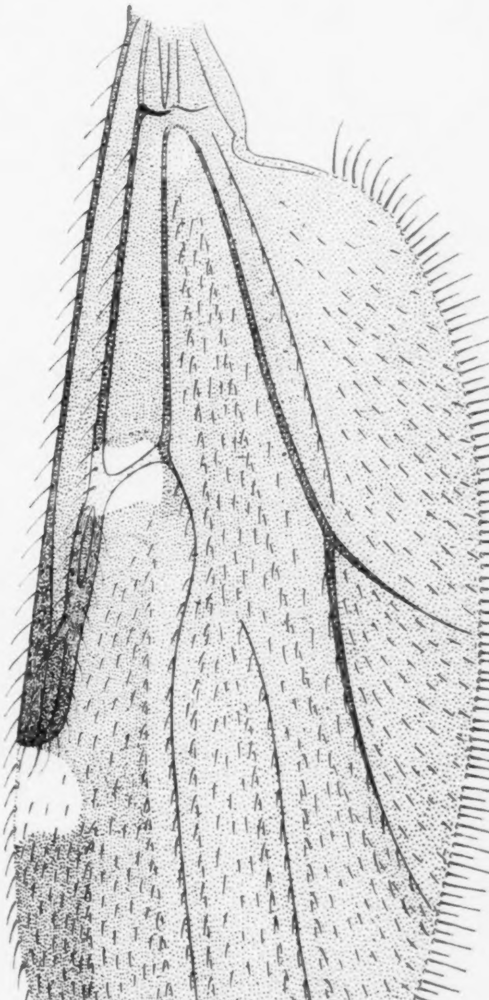

FIG. 2

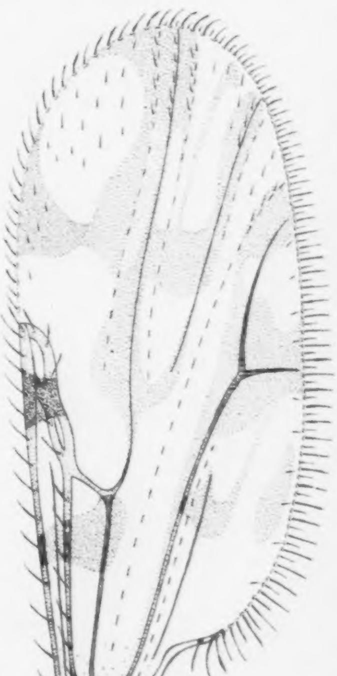

FIG. 3

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FURTHER EXPERIMENTS WITH *ANOPHELES PLUMBEUS*, STEPHENS; ITS INFECTION WITH *P. FALCIPARUM* IN ENGLAND; ALSO NOTES ON THE APPARATUS AND TECHNIQUE EMPLOYED

BY

B. BLACKLOCK

AND

HENRY F. CARTER

(*Received for publication 28 September, 1920*)

PLATE IX

In a recent paper (1920) we recorded the results obtained from dissections of laboratory-bred females of *Anopheles plumbeus*, which had fed on patients infected with *Plasmodium vivax*. The present paper gives the results of additional experiments with females fed on patients infected with *P. vivax* (mosquitoes kept at room temperature) and of feeding examples of this mosquito, bred in the same way, on a patient whose blood contained *Plasmodium falciparum* (mosquitoes kept at 28° C.).

EXPERIMENTAL

This work was carried out at Liverpool during the months of May and June, 1920.

I. *Experiments with laboratory-bred* A. PLUMBEUS *and* P. VIVAX *at room temperature.*

The mosquitoes used in these experiments were kept in a cupboard in the laboratory. Any that died after the infected feed were, if possible, dissected and examined in 0·85 per cent. sodium chloride. Examination of the peripheral blood of the two cases on

which these experiments were performed (B and C on the first case, D on the second) showed numerous parasites in both, but the process of exflagellation was observed in the second only.

TABLE I.

Showing the results of feeding laboratory-bred *A. plumbeus* on patients infected with *P. vivax*.

Exp.	Date Fed	Number					Temperature used Min. – Max.	Remarks
		Fed	Dis-sected	Infected	Gut	Sal. Glands		
B	8.5.20	5	5	...	...	...	13° C.-22° C.	Females killed from 10th to 22nd day after infected meal.
C	8.5.20	5	5	...	...	...	13° C.-22° C.	Females killed (one died 19.5.20) 14th to 18th day after infected meal.
D	14.5.20	2	2	...	...	...	13°C.-22°C.	Females killed on 18th and 19th day after infected meal.

II. *Experiments with laboratory-bred* A. PLUMBEUS *and* P. FALCIPARUM.

The mosquitoes used in this experiment were kept in an incubator at 28° C. The blood of the patient upon which the mosquitoes fed was examined immediately before feeding; gametes were present, but the process of ex-flagellation was not observed.

TABLE II.

Showing the results of feeding laboratory-bred *A. plumbeus* on a patient infected with *P. falciparum*.

Exp.	Date Fed	Number					Temperature used	Remarks
		Fed	Dis-sected	Infected	Gut	Sal. Glands		
A	12.6.20	12	11	1	1	...	28° C.	Ten had died by the 8th day—one unfit for dissection. Two killed on the 8th day—one infected.

The infected female was killed on 20th June, 1920; the gut contained four large oöcysts, the largest $60{\cdot}7\mu$ by $52{\cdot}4\mu$, the smallest $51{\cdot}0\mu$ by $48{\cdot}4\mu$, all with sporozoites.

In this experiment the females died early, and on examination, within an hour or two of death, their abdomens were crowded with yeasts and bacteria and the contents macerated. On the eighth day two females still survived, but to ensure reliable dissections they were killed. Infection of the gut was observed in one of them.

SUMMARY

I. Of twelve females of *Anopheles plumbeus* fed once on one or other of two cases of simple tertian malaria (*P. vivax*), and subsequently kept at room temperature (max. 22° C., min. 13° C.) none became infected.

II. Of twelve females of *Anopheles plumbeus* fed once on a case of malignant tertian malaria (*P. falciparum*), and subsequently kept at 28° C., none lived longer than eight days after the infected feed; one contained oöcysts in the mid-gut.

APPARATUS AND TECHNIQUE

The article referred to above (1920) in connection with the experimental work also contained a short account of the technique adopted at that time; but this has since been considerably improved upon, and in view of its importance in mosquito-infection work in the laboratory, we have here embodied a description of the methods and apparatus used during the period in which the experiments recorded were carried out.

Larvae in various stages were collected from rot-holes in trees in the vicinity of Liverpool, mainly during the months of March and April, 1920. They were brought to the laboratory in glass jars and placed in inverted bell-jars (mounted on wooden stands) containing water and sediment from the tree-holes. Low, wide-mouthed bell-jars (6 inches deep, 12 inches diameter) were found most convenient, and were filled to a depth of about two or three inches with the water and sediment. Numbers of larvae were maintained in each jar by judiciously supplying them with dry, powdered cockroaches; they fed voraciously on this diet, and the rate of their development could

apparently be controlled by the frequency of its application. Every morning the larval jars were examined, and all pupae* removed to small glass containers mounted on wooden trays. The trays consisted of wooden platforms ($\frac{3}{4}$-inch thick) raised on runners, two and a half inches high, at each end, and pierced in eight places by circular holes to carry the pupal containers. The dimensions of the trays most often used were length 27 inches, width 15 inches, but smaller one (18 inches by 10 inches) were also available, though found to be of less convenient size. The pupal containers used in the larger trays were small potted-meat jars of a common pattern (internal diameter $2\frac{1}{2}$ inches, depth about $1\frac{1}{2}$ inches) provided with thick laterally projecting rims or flanges, and were sunk into the trays in such a way that the rims were flush with the platforms. Each of the larger trays was provided with a double row of four evenly-spaced containers, so that each of the latter was in the centre of an area of the platform approximately nine inches square, and separated from the edge of the tray or the next jar by about three inches. To avoid overcrowding, not more than ten or a dozen pupae were placed in one jar, but not infrequently less than this number was present since the daily supplies of pupae were kept separate. If much larger numbers of pupae were placed in the containers or if young and old pupae were indiscriminately mixed, the mortality, particularly among emerging adults, was found to be increased. Even when the greatest care was exercised, partially or completely emerged adults were sometimes found drowned, although the employment of small 'bridges' of thick paper (renewed daily) apparently rendered the process less perilous. Immediately after the transference of pupae from the larval jars to the trays, the containers were covered with glass cylinders, the upper ends of which were closed by pieces of mosquito-netting attached by rubber bands. Considerable difficulty was at first experienced in obtaining cylinders of suitable sizes and at reasonable cost, but subsequently this was overcome by using glass engine-gauges. These are made in a variety of sizes of very thick, but clear glass with ground edges, and are easily procurable and altogether satisfactory for the purpose

* The material collected from the rot-holes naturally included large numbers of larvae of *Ochlerotatus geniculatus*; the pupae of this species were separated from those of the *Anopheles* with ease during the daily segregation and thus a protracted search for minute larvae avoided.

required. The cylinders selected for covering the pupal containers were four inches in length with an internal diameter of three and a half inches. The adults were removed from these each morning, and the females and a few males transferred to narrower cylinders (5 inches long, $2\frac{1}{2}$ inches diameter) more suitable for feeding purposes. Transference was accomplished by slipping a piece of stiff paper under the large cylinder on the pupal tray and removing it bodily to a simple apparatus which enabled the insects to be blown from one cylinder to the other. This apparatus was formed of two platforms of stout cardboard, wired to retort-rings fitted on a stand; one of the platforms was placed above the other, and consisted of two superimposed sheets of cardboard (approx. 10 inches by $6\frac{1}{2}$ inches) fastened together at their sides but slightly separated from one another and pierced in the middle by a circular aperture 2 inches in diameter. A third and slightly narrower sheet of cardboard was pierced in a similar manner, but nearer to one end; it could slide between the other two pieces, and, if pushed home, close the apertures in the upper and lower sheets. The lower platform consisted of a single sheet of cardboard, and acted as a moveable tray for the lower and smaller cylinder into which the mosquitoes were to be transferred. The latter was first screened at one end, and then the open end adjusted to the aperture on the under side of the upper platform; the large cylinder containing the mosquitoes was placed on the upper side of the platform over the aperture and the paper slipped from beneath it. The sliding sheet was then pulled out a distance sufficient to allow its aperture to coincide with those of the upper and lower sheets forming the upper platform, and the insects blown downward. For this purpose it was found advisable, first to cause the mosquitoes to fly about and then to direct them towards the aperture by blowing through a piece of rubber tubing. When all the mosquitoes had entered the lower cylinder the sliding sheet was pushed home and the cylinder removed, after first slipping paper between its open end and the upper platform. Mosquito-netting was then fixed over the open end, and the cylinder subsequently placed on damp filter paper in a petri dish. Except the single meal of blood received from the patient, the adults were fed only on split and moistened raisins, to which they always had access; the raisins were placed upon the

netting covering the upper ends of the cylinders, and were renewed every three or four days. From fifteen to twenty mosquitoes, chiefly females and of nearly the same age as possible, were kept as stock insects in each of these feeding-cylinders, in a shaded corner of the room or in a cupboard. When a suitable case presented itself, one of the gauze-covered ends of the cylinders was applied to the skin, usually the inside of the fore-arm, and allowed to remain until most or all of the females had engorged. *A. plumbeus* bites readily, and it was not found necessary to shade the cylinders during this operation; but, in order to induce as great a number as possible of the females contained in the cylinder to engorge rapidly, that portion of the patient's skin where feeding was to take place was usually wiped with a hot, damp cloth, and the cylinder occasionally inverted so that females which had settled on the gauze covering the upper end came into actual contact with the skin and were thus stimulated to bite. The mosquitoes were then placed in the incubator or left in the room according to the conditions of the experiment. Subsequently they were removed from the cylinders when required for dissection. In most of our work, after the lapse of four or five days from the blood meal, one or two females were dissected daily. Their separation from the other females and removal from the cylinder was accomplished by means of the transferring apparatus described above. A sliding sheet with a smaller aperture (one inch diameter) was, however, substituted for the one previously mentioned. The rubber blow-tube was attached to a six-inch length of half-inch glass tubing, of which that end inserted into the rubber tubing was covered with a piece of gauze. The cylinder, with paper instead of the gauze at the lower end, was placed on the upper platform of the apparatus, the sliding sheet pulled out so that the apertures coincided, and the glass-tubing thrust through the paper. A single female was then drawn into the tube by suction, the glass withdrawn and the sliding sheet pushed home. The mosquito was then killed with chloroform and dissected in the usual manner.

REFERENCE

Blacklock, B., and Carter, H. F. (1920). The Experimental Infection in England of *Anopheles plumbeus*, Stephens, and *Anopheles bifurcatus*, L., with *Plasmodium vivax*. *Ann. Trop. Med. and Parasit.* Vol. XIII, pp. 413-420.

EXPLANATION OF PLATE IX

Apparatus used in experimental-infection work with mosquitoes and malaria:—

A—Inverted bell-jars containing stock larvae.

B—Pupal trays, showing the small pupae-containers and the screened cylinders for reception of emerged adults.

C—Feeding-cylinders, screened at both ends with raisins on top, and standing in petri dishes on damp filter-paper; for stock adults and experimental females.

D—Transferring apparatus, showing retort-stand with the two platforms fitted on the rings, and cylinders in position for the transferring process; also the rubber blow-tube with glass extension for isolation of experimental females.

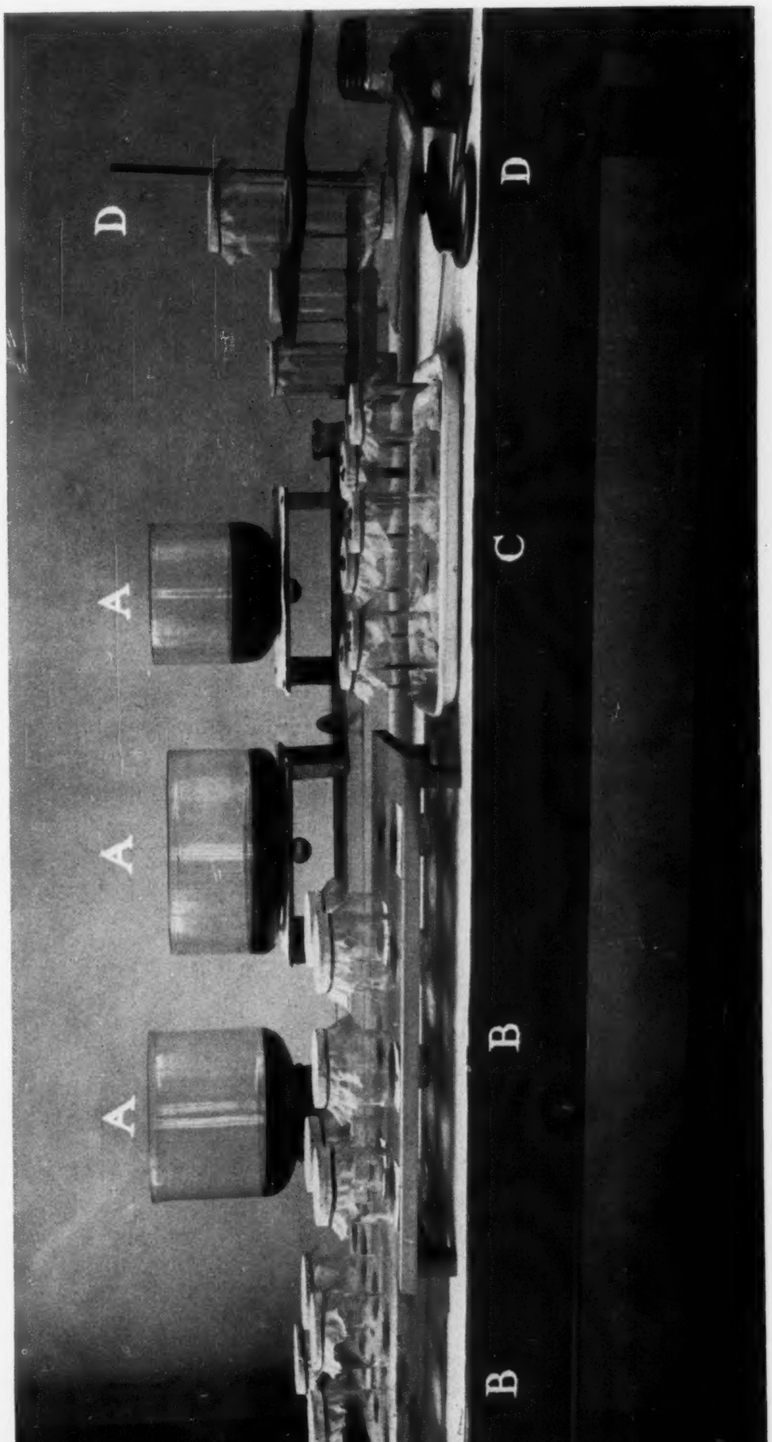

Photo. by Miss M. Brown

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HUMAN INTESTINAL PROTOZOA IN NORTH QUEENSLAND

BY

P. A. MAPLESTONE

From the Australian Institute of Tropical Medicine, Townsville

(*Received for publication* 1 *October*, 1920)

This investigation was undertaken with the object of ascertaining if carriers of *Entamoeba histolytica* exist among the healthy population of North Queensland, as in other parts of the world. This has been shown in England by Yorke and others (1917), and by Matthews and Smith (1919), and in Egypt by Wenyon and O'Connor (1917).

In the present series the number of people examined is five hundred, and the specimens were obtained from among a number of about one thousand five hundred, which were collected by members of the "Hookworm Campaign" staff, during their investigation of that disease. With the exception of seventy-one stools from the Townsville Orphanage, they were chosen quite at random. They include all ages of the community, from 1 year to 80 years of age, and embrace a wide area of country to the North and West of Townsville, within a radius of seventy miles of the town. All the houses are small, and built of wood or galvanized iron, and are not crowded together, in many cases miles separating them. The conservancy system is pans, and the privies are not fly-proof.

From their manner of collection, the specimens were at least three, and perhaps as much as fourteen, days old before being examined, therefore no vegetative forms of the various organisms were seen, but only their cysts. And for the same reason only one examination of each case was possible. This point should be borne in mind throughout the perusal of the paper, because it has been

shown by Carter and others (1917) that only about one quarter of the total *Entamoeba histolytica* infections are revealed at the first examination, and similarly one-third of the *Entamoeba coli*, and one-half of the *Lamblia intestinalis* infections only are found.

The following protozoal cysts were seen, viz.:—*Entamoeba histolytica* (Schaudinn), *Entamoeba coli* (Losch), *Lamblia* (*Giardia*) *intestinalis* (Lambl), *Tetramitus* (*Chilomastix*) *mesnili* (Wenyon). Other cysts of a vegetable nature were encountered, which are mentioned at the end of the paper.

General results. The total figures are given in Table I, and call for no special comment.

TABLE I.

Type of infection	No. of stools examined	No. infected	Percentage
E. histolytica	500	23	4·6
E. coli	500	134	26.4
L. intestinalis	500	59	11·8
T. mesnili	500	11	2·2
'? *cyst*'	500	9	1·8

Mixed infections occurred as follows:—

E. histolytica, *E. coli*, and *L. intestinalis*, five times.

E. histolytica and *E. coli*, five times.

E. coli and *L. intestinalis*, sixteen times.

E. coli and '? *cyst*,' three times.

E. coli and *T. mesnili*, once.

For purposes of comparison, Table II has been compiled from a paper by Carter and others (1917), with the addition of the figures given in a series of examinations by Matthews and Smith (1919), and those of the present paper.

TABLE II.

		Present series	Matthews and Smith (1919)	Carter and others (1917)	Wenyon (1915)	Dobell (1916)	Jepps (1916)	Matthews and Smith (1917)
		1	2	3	4	5	6	7
No. examined	Dys. ...	...	...	910	556	90	153	...
	Non-dys. ...	500	450	...	...	110	204	250
Total examined ...		500	450	910	556	200	426	250
E. histolytica ...		4·6	1·5	10·3	10·8	11·0	7·7	8·0
E. coli		26·8	6·7	25·4	39·0	40·9	25·8	19·2
L. intestinalis		11·8	6·0	18·6	16·0	19·5	19·0	8·0
T. intestinalis		...	...	1·2	1·6	2·4	...	1·7
T. mesnili		2·2	1·5	2·7	0·5	7·8	...	2·0

All the figures in the above table are in percentages. It must be borne in mind that columns 1 and 2 give the results of a single examination, and the remaining columns are the aggregate of repeated examinations of each case.

The objection may be raised that some of the figures refer to dysenteric, and others to non-dysenteric cases. But Wenyon and O'Connor (1917) have shown that there is very little difference between the two classes of case, as far as percentage of carriers is concerned. This fact is well sustained in the table given above.

It is obvious, allowing for the single examination, that the figures in the present series are high, especially in regard to *E. histolytica*, *E. coli*, and *L. intestinalis*. But when compared with those of a series of examinations by Matthews and Smith (1919), in which they made one examination only, of a number of

non-dysenteric cases, it is seen that they are well within the bounds of the figures for England.

This is shown in Table III, in which all the figures are in percentages, and are the result of a single examination of healthy people in every case.

TABLE III.

	No. examined	*E. histolytica*	*E. coli*	*L. intestinalis*	*T. mesnili*
Present series	500	4·6	26·8	11·8	2·2
Batch 1	263	3·0	12·1	4·5	...
Batch 2	241	6·6	23·2	7·5	1 case
Batch 3	230	3·9	14·8	6·1	...
Batch 4	98	6·1	21·4	8·2	...
Batch 5	84	8·2	22·4	11·8	1 case
Batch 6	104	5·8	17·4	6·7	...
Batch 7	78	12·8	23·1	10·2	...

Age incidence. The effect of age on the incidence of infection is shown in Table IV. It is in agreement with the findings of Matthews and Smith (1919), and supports the tentative view expressed by them in this connexion, that the proportion of young people infected is higher than that of adults. The present investigation covers a much wider range of ages than that of the above observers, as it embraces people from 1 year to 80 years. Nevertheless, it is open to the objection, that the numbers in the various age-groups are somewhat small, and, consequently, do not give quite accurate results, which would be obtained if a higher number were examined. This is especially noticeable in the Ophanage group 1 to 5 years, with only nine cases, and three infections by *E. coli*, thus giving a percentage of 33·3 per cent., which is obviously much too high. The fact of the relatively high incidence of *L. intestinalis* among children is well shown. This is also pointed out by the above workers.

In this, and all subsequent tables, *T. mesnili* and '*? cyst*' are not shown, because the actual number of these infections is too small for such comparison.

TABLE IV.

(PEOPLE IN PRIVATE HOUSES)

Age group in years	No. examined	Percentage infected		
		E. histolytica	*E. coli*	*L. intestinalis*
1-5	48	4·2	4·2	22·9
6-10	55	5·5	12·7	23·6
11-15	41	9·75	41·5	22·0
16-20	39	5·1	23·1	10·2
21-30	72	6·9	29·2	4·2
31-40	57	1·75	26·3	8·8
41-80	117	1·7	23·9	5·1
(ORPHANAGE CHILDREN)				
1-5	9	0·0	33·3	11·1
6-10	42	4·8	50·0	14·3
11-15	200	10·0	55·0	20·0

In the above table it will be noted that the Orphanage has been given separately. This is because 33 per cent. of all the children examined live in it, and as they are living with only one or two adults, it is not quite the same as the children living in private houses with a relatively large number of adults.

Sex incidence. The equality with which the three types of organism under consideration is distributed between the sexes is remarkable, and is shown in Table V.

TABLE V.

Sex	No.	*E. histolytica*	*E. coli*	*L. intestinalis*
Male	274	4.9	25·1	12·8
Female	218	4·5	23·4	11·9
Sex ?	8	...	...	...

Matthews and Smith (1919), in a small series of seven houses, showed that when one person in a given house is infected, the other members of the same household show a relatively high percentage of infection. The same has been worked out for the present series, and is shown in Table VI.

On account of the large number of houses from which cases have been examined, the details of infection are not given for each house separately. They are shown as average percentages of the infected population. This figure was obtained by working out the percentage of people infected in each house in which infection occurred, and then striking the average of these percentages.

The Orphanage is again given separately, because with its population of seventy-one it would have an undue influence on the totals of the private houses, whose average population per house is only three to four.

TABLE VI.

PRIVATE HOUSES

Type of infection	Total No. of houses examined	No. of houses infected	Percentage	Total population of infected houses	No. of population infected	Average percentage infected per house
E. histolytica	158	13	8·2	64	19	39·5
E. coli	158	66	41·8	223	99	54·2
L. intestinalis	158	25	15·8	95	48	54·3
ORPHANAGE						
E. histolytica	1	1	100	71	4	5·6
E. coli	1	1	100	71	35	49·3
L. intestinalis	1	1	100	71	11	15·5

It appears in the above table that, including the Orphanage, there are one hundred and five houses with infections of one kind or another in them. But the actual number of houses containing infections is only seventy-five, because some houses have two or all types of infection in them. Similarly among the people two hundred

and sixteen infections are distributed between one hundred and eighty-five individuals.

Further, it is noticed that the figures in the last column are higher than the percentages which would result from comparing the total population of infected houses and the number of population infected. This is because some houses with only one inhabitant, who is infected, tend to raise the average.

There is no apparent reason why the Orphanage figures do not more closely agree with the averages for the private houses. Nevertheless, they are distinctly higher than the total infections found, as will be seen by comparing them in Table VI with those of Table I.

The fact of the equal liability of the sexes to infection and that of the high incidence of infection in houses which contain infected people, when taken together seem to be of some value, as an indication of the probable mode of spread of infection.

All the adult males are employed in outdoor work, and the females are occupied in house work. Therefore, the infection most likely occurs in the neighbourhood of houses, as outdoor work has no apparent influence on the infection rate, and vice-versa.

Wenyon and O'Connor (1917) in a series of experiments proved that house-flies can act as the carriers of cysts of *E. histolytica*, and when it is remembered that in the houses under consideration all the privies are of the dry-earth type, and by no means fly-proof, the idea of flies being active agents in the spread of infection, at all events in this district, is worthy of consideration.

Origin of the infection. As a result of inquiries among the twenty-three carriers of *E. histolytica*, it is found that, with one exception, they have all lived in their present houses many years, and in most cases all their lives. The one exception was at the war for three years, but never had dysentery or diarrhoea. All except one, who was born in Ireland, and has been in Australia twenty-seven years, were born in this country, and have not been out of it, except the soldier.

Two of them have had attacks of dysentery, both some years ago, one in the present abode, and one in Western Australia. The true nature of these attacks is not obtainable.

No work has been done on returned Australian soldiers to find

if there are carriers of *E. histolytica* among them. Nevertheless, it is practically certain they exist, because carriers in the British army have been found by Wenyon (1916), Jepps (1916), Matthews and Smith (1917), Turner and Taylor (1919), and many others. And the same has been found in the American army by Kofoid and others (1919). Australian soldiers were living under identical conditions as the soldiers of the above two armies, and, further, many of them had dysentery. It is, therefore, reasonable to assume that there are carriers among them. But H. Johnston (1909) has collected records of six or seven cases of amoebic dysentery or liver abscess occurring in Australia prior to that date. Therefore, *E. histolytica* has probably existed in Australia for many years, and, as in many other countries, only occasionally causes disease. Consequently, the almost certain introduction of a large number of carriers among the returned soldiers need not necessarily be followed by an increase in incidence of the disease.

Special considerations. *E. hystolytica* has shown nothing worthy of special notice. *E. coli*: Small cysts of this organism have been relatively common. By small cysts is meant those from 11μ to 14μ. This in a total of one hundred and thirty-four infections, a high proportion, as shown by Smith (1919). *L. intestinalis* has been found about an equal number of times in each of the two types described by Matthews (1918), viz., the usually described, brown-staining variety in iodine, and the smaller bluish type described by the above observer. They either occurred alone or both in the same stool. *T. mesnili* in some stained preparations showed the chromatin of the nucleus evenly distributed around the nuclear membrane, and hence did not present the 'signet-ring' type of nucleus described by Matthews (1918) as typical. *Entamoeba nana* (Wenyon) was not found at all. This is somewhat strange, as it seems to occur in most other parts of the world, in company with the protozoa found at this examination. But the number of cases examined is too small on which to make a definite pronouncement as to its presence or absence in Australia, and it will very likely appear at subsequent examinations. *I. cysts* (Wenyon) were encountered five times. In one case these cysts, with the iodine vacuole distinct, were seen at the serial examination. But when the same case was examined after treatment for *Agchlystoma duodenale*,

large numbers of the same cysts were seen, but on this occasion none showed the iodine vacuole.

Blastocystis hominis was fairly common, more especially when reasonably fresh stools were examined. The actual number of times it occurred was not recorded. A single rather interesting observation in connection with this cyst has been noted. A case that showed large numbers of *I. cysts* in a formed stool at the serial examination was again examined after treatment for *A. duodenale*, when the stool was liquid. On the second examination no *I. cysts* were found, but the stool was full of *B. hominis*, none of which were found at the first examination. Wenyon (1917) mentions the development of *B. hominis* and diarrhoea concurrently in a case he was controlling for *E. coli*, and suggests a possible connection between the two, but draws no definite conclusion. The above case, observed at Townsville, raises the question whether *B. hominis* may not appear because of the diarrhoea artificially induced. And the same thing may have occurred in Wenyon's case, although there the diarrhoea was not brought on by the use of drugs. But O'Connor (1919), in a later paper, seems to trace some connexion between *B. hominis*, *I. cysts*, and some other vegetable cysts, and a special form of diarrhoea of which he has observed fifteen cases.

'*? cysts.*' In fresh preparations, both in saline and iodine solution, this cyst was to all appearance very like *E. nana*. It is a small cyst varying in shape from a distinct oval to one almost circular. It is 5μ to 12μ in its long diameter, and contains a few refractile granules, which might easily be mistaken for indistinct nuclei, such as are seen in *E. nana*. But in preparations stained with iron-haematoxlyn the granules are seen as small, darkly-staining dots, which are quite homogeneous and show no nuclear structure. They vary from one to seven in number. After prolonged search of stained preparations a few budding forms were found, thus definitely proving its vegetable origin. Attention has only been drawn to it because of its likeness to *E. nana*.

Eggs of the following intestinal worms were found during the course of the examination, viz.:—*Agchylostoma duodenale*, *Oxyuris vermicularis*, *Trichuris trichiura*, and those of a *Hymenolepis* sp. (probably *H. nana*). The larvae of *Strongyloides stercoralis* were fairly often encountered.

The number of times these infections occurred is not given because many are missed when the stools are not centrifugalised, and, further, they will be published in full, and for a much greater number of cases, in the reports of the 'Hookworm Campaign.'

SUMMARY

The protozoa of the human intestine are substantially the same in Australia as in other parts of the world where similar examinations have been carried out, and they occur in approximately the same proportion of cases, among healthy people.

Confirmation is given to the view that the incidence is higher in children and young adults than in people of more mature age.

Evidence has been put forward to show that flies are very probably carriers of the infection.

In conclusion, I wish to express my thanks to Dr. Breinl for his readiness always to discuss doubtful cases, and also for his assistance and suggestions in connection with the literature; and to Dr. Willis, of the 'Hookworm Campaign,' and the members of his staff, for free access to their material, and for obtaining for me any information I required from any of the cases examined.

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A NOTE ON THE OCCURRENCE OF CERTAIN CESTODES IN NEW HOSTS

BY

T. SOUTHWELL

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In going through the collection of Cestoda in the Liverpool School of Tropical Medicine, the following were found in new or unusual hosts:—

1. *Avitellina centripunctata*, Rivolta, 1874.
   = *Taenia centripunctata*, Rivolta, 1874.
   = *Stilesia centripunctata* (Rivolta), Stiles, 1893.
   = *Stilesia centripunctata* (Rivolta), Railliet, 1893.
   = *Stilesia centripunctata* (Rivolta), Gough, 1909.

This worm occurs normally in sheep. Ward obtained it from *Bos taurus* in 1895. Numerous specimens of this worm were collected from the stomach of an ox by Professor Yorke, 1915, in the military slaughter-house, Freetown.

2. *Stilesia hepatica*, Wolffhügel, 1903.
   = *Stilesia hepatica* (Wolffhügel), Gough, 1908.
   = *Stilesia sjöstedti*, Führmann, 1909.

This species has previously been obtained from sheep, goats, and wild ruminants.

Our collection contains specimens from the following hosts:—

(*a*) Ox stomach. Several specimens collected by Professor Yorke from the European slaughter-house, Freetown, December, 1914.

(*b*) From cattle. Several specimens collected by Dr. J. W. S. Macfie, Accra, Gold Coast, September, 1915.

(*c*) From buffalo's stomach. Several specimens collected by Professor Newstead and Dr. Davey, Upper Shiré, Nyasaland, 1911.

(*d*) From a duiker (*Cephalophus monticola*). Two specimens collected by Professor Yorke, N.E. Rhodesia, July, 1912.

3. *Stilesia globipunctata* (Riv., 1874), Railliet, 1893.

This species is found in sheep and goats. We have several specimens from the bile ducts of a water-buck, *Cobus ellipsiprymnus*; collected by Dr. A. Kinghorn in Rhodesia, 1908.

4. *Moniezia oblongiceps*, Stiles and Hassall, 1893.

This species usually occurs in sheep, and has been found in *Coassus* sp. We have two specimens and some fragments from a water-buck, *Cobus ellipsiprymnus*, collected by Professor Yorke at Ngoa, N.E. Rhodesia, in July, 1912.

5. *Moniezia expansa* (Rud., 1810), R. Blanchard, 1911.

This species occurs in sheep, cattle, deer and other ruminants. We have fragments from a duiker, *Cephalophus monticola*, collected by Professor Yorke in N.E. Rhodesia, in July, 1913.

6. *Metroliathes lucida*, Ransom, 1900.

This species has been recorded from turkeys and chickens. We have several specimens from guinea-fowls (*Numida ptilorhyncha*); collected by Professor Newstead and Dr. J. B. Davey, Upper Shiré River, Nyasaland, 1911.

7. *Davainea tetragona* (Molin, 1858), R. Blanchard, 1891.

This species is found in chickens. We have a few specimens from guinea-fowls (*Numida ptilorhyncha*), collected by Professor Newstead and Dr. J. B. Davey, Upper Shiré River, Nyasaland, 1911, and also by Dr. Arnold in the Transvaal.

8. *Davainea cesticillus* (Molin, 1858), Blanchard, 1891.

This species has hitherto been recorded only from chickens and turkeys. We have two specimens from guinea-fowls (*Numida ptilorhyncha*); collected by Professor Newstead and Dr. J. B. Davey, Upper Shiré River, Nyasaland, 1911.

ERRATUM

Vol. XIV, p. 296, line 16. For '*Metroliathes lucida*' read '*Metroliasthes lucida.*'

9. *Taenia* sp. (*saginata* ?).

Numerous fragments from a goat, *Capra cylindricornis*; collected by Dr. J. W. S. Macfie, Accra, Gold Coast, 1919.

No head was present. The fragments consisted of one hundred and fifty-five segments, each measuring, on an average, 7·5 mm. long and 4·5 to 5·5 mm. broad. Only about thirty of these segments contained genitalia, the rest being sterile, and longer and narrower than the segments containing genitalia. The genital pores were irregularly alternate and situated laterally, slightly posterior to the middle. The genital organs resembled, exactly, those of *T. saginata*. The main stem of the uterus was long and somewhat narrow, and had from fourteen to nineteen lateral branches.

Eggs. No mature eggs were found, and measurements cannot therefore be given.

The occurrence of a species of Taenia in a goat calls for comment, for, as far as we are aware, no species of this genus has hitherto been recorded from a ruminant. Our fragments were obtained by Dr. Macfie from a goat, killed in the slaughter-house at Accra. There can be no doubt that the occurrence of this parasite in a goat is accidental; this opinion is corroborated by the presence of numerous sterile segments, for it is well known that the parasites found in unusual hosts tend to become sterile.

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TWO NEW *CYLICOSTOMUM* SPECIES FROM THE HORSE

BY

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INTRODUCTION

The Cylicostomes—worms of the Equidae (horse, donkey, mule and zebra)—comprise very numerous species. Our knowledge of the various forms has increased, particularly during the last few years. At the present time, the known species of the genus *Cylicostomum* are twice as numerous as those described by Looss in 1901. This fact, which is of great systematic interest, must be a starting point for anatomical, histological and biological studies concerning the life-history, and especially the position of the various forms within the genus *Cylicostomum*. Looss (1901) discusses in his important monograph on the 'Sclerostomes of Horses and Donkeys in Egypt' the possibility of the division of the genus *Cylicostomum;* he found that with the exception of some isolated forms, the majority of the species could be classified in certain groups. Similarly, the new species which have been described since the appearance of Looss' work can also be classified; the majority can be referred to one or other of Looss' groups, but the number of isolated forms is increased.

Recently, new genera have been erected for certain forms belonging to the genus *Cylicostomum*, s.l., namely, *Poteriostomum* (Quiel) = *Hexodontostomum* (Ihle) and *Craterostomum* (Boulenger); but *Poteriostomum* must be considered only as a variety of *C. ratzii*, and since the chief characters of both forms do not differ essentially from those of the genus *Cylicostomum*, I think that the establishment of this new genus (*Poteriostomum*) is not justified. Moreover, *C. ihlei*, sp. n., which has undoubtedly the general

characters of the genus *Cylicostomum*, should also be referred on account of the structure of its mouth capsule to the genus *Poteriostomum*; this, however, seems to me incorrect.

Concerning the new genus *Craterostomum* (Boulenger), I think that this is very closely related to *C. acuticaudatum*, mihi = *C. mucronatum* (Ihle), and is perhaps even identical with the latter; but it must be observed that the characters of *C. acuticaudatum* correspond to those of the genus *Cylicostomum*.

In the following pages I give a brief description of two new species of the genus *Cylicostomum* found in the large intestines of Hungarian horses.

Cylicostomum ihlei, sp. n.

This new species, named in honour of Prof. I. E. W. Ihle (Utrecht), exhibits, as regards the structure of the mouth capsule, a decided resemblance to *C. ratzii*, mihi. The size of the worm is generally smaller than in the mentioned species. The males were

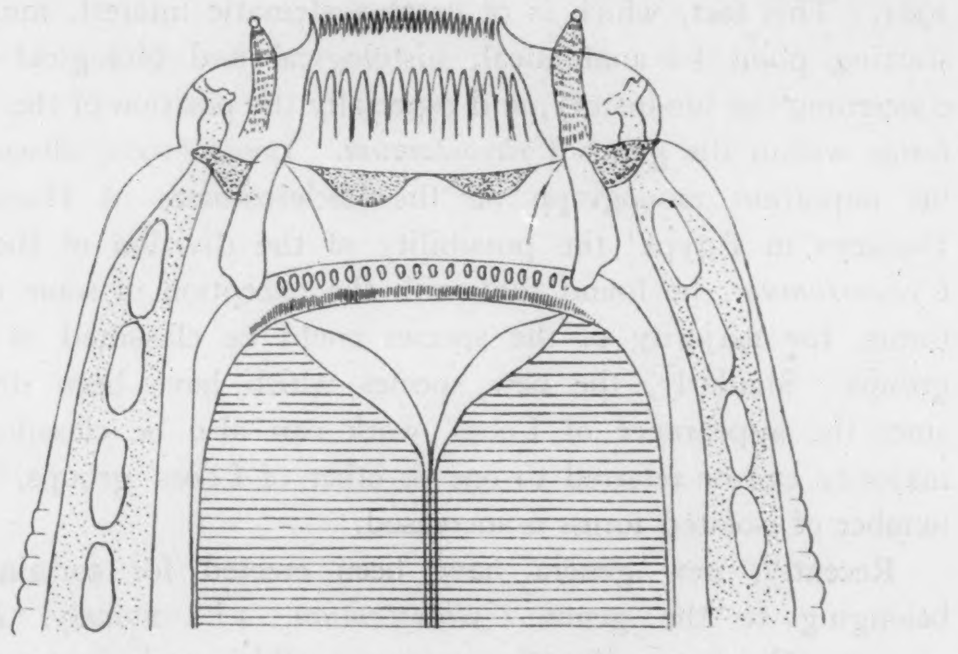

Fig. 1. *Cylicostomum ihlei*, sp.n. Anterior extremity, dorsal view. × 180.

from 9 mm. to 10 mm. long, the females at most 14 mm. long; with a maximum thickness of 595μ in the male and 900μ in the female. The constriction separating the mouth collar from the body is feebly marked; mouth collar about as high (40μ to 43μ) as it is thick.

The submedian head papillae are conical, their extremities rounded and notched, their length nearly 18 μ; lateral papillae large and not projecting beyond the surface of the mouth collar. The mouth opening is circular.

The external leaf-crown, originating from the posterior margin of the mouth collar, consists of about sixty slender and sharply-pointed

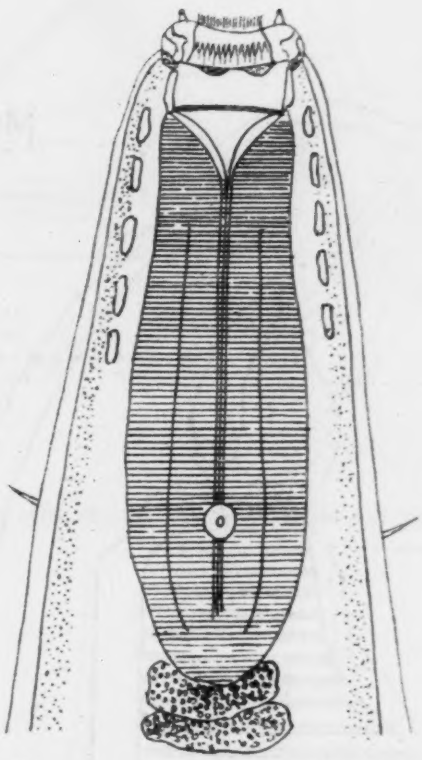

FIG. 2. *Cylicostomum iblei*, sp.n. Anterior end of the body, ventral view. × 90.

leaves, similar in shape to those of *C. ratzii*, mihi. The internal leaf-crown, composed of about forty to forty-six large pointed leaves, arises from immediately behind the anterior border of the mouth capsule; the elements of the internal leaf-crown have in general a similar shape and appearance to *C. ratzii*, and their tips extend forwards beyond the mid-plane of the mouth collar.

The mouth capsule is nearly cylindrical, its posterior diameter is hardly greater than the anterior; the maximum breadth is 148 μ, and the maximum depth 67 μ; the walls slightly increase in thickness from before backwards. In certain worms belonging to this species,

the external surface of the anterior margin of the mouth capsule is characterised by the presence of eight semi-circular (in dorsal or ventral view) ledges,* their arrangement is regular, namely: between every two submedian head-papillae there is a pair of ledges, and between every lateral and submedian head-papillae a single ledge. A similar peculiarity exists also in *C. acuticaudatum* (Kotlán, 1919) = *C. mucronatum* (Ihle, 1920). Dorsal gutter absent.

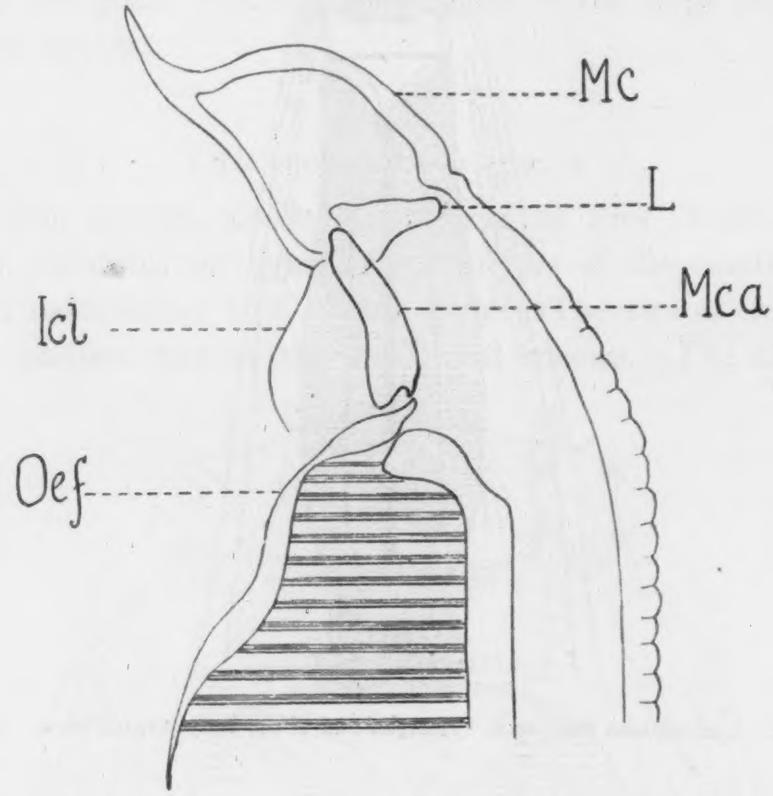

FIG. 3. *Cylicostomum iblei*, sp.n. Optical longitudinal section of mouth collar, mouth capsule and adjoining part of the oesophagus. × 345. Icl = internal cuticular lining; L = semi-circular ledge; Mc = mouth collar; Mca = mouth capsule; Oef = oesophageal funnel.

The oesophagus has a length of 680μ to 765μ; it is almost cylindrical in shape up to the nerve ring, and behind this structure it slightly increases in thickness up to a maximum of about 200μ to 253μ. Cervical papillae and excretory pore lie over the posterior third of the oesophagus.

* These thickenings are entirely absent in certain specimens of these worms.

The posterior extremity of female resembles that of *C. elongatum* (Looss), but the base of the tail is stouter; the distance between vulva and anus is about 135μ to 148μ.

FIG. 4. *Cylicostomum iblei*, sp.n. Posterior extremity of male, lateral view. × 90.

FIG. 5. *Cylicostomum iblei*, sp.n. Posterior extremity of male, ventral view. × 90.

The bursa of the male has a moderate-sized median lobe; the lateral lobes are distinctly separated. The dorsal rays D_2 and D_3 are equal in length to D_1; the prebursal papillae are rather long.

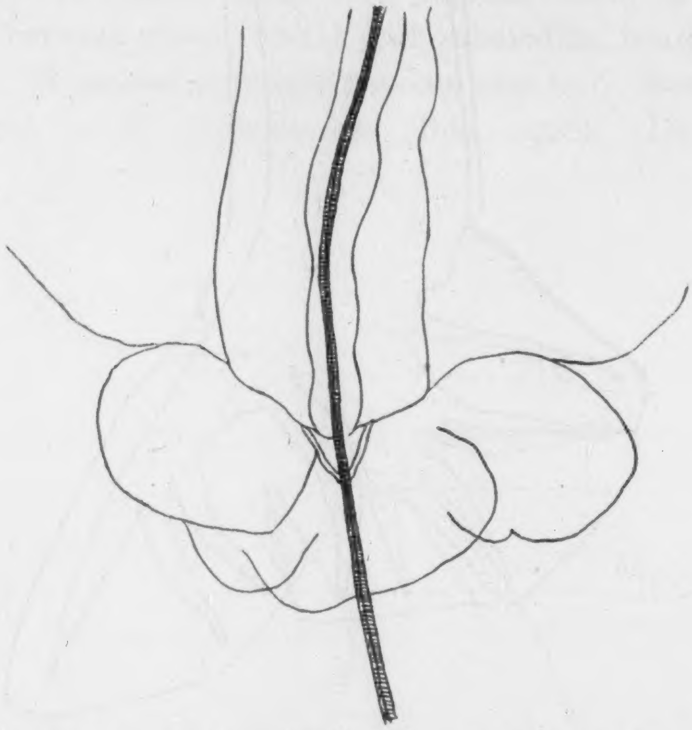

FIG. 6. *Cylicostomum iblei*, sp.n. Genital appendages, ventral view. × 180.

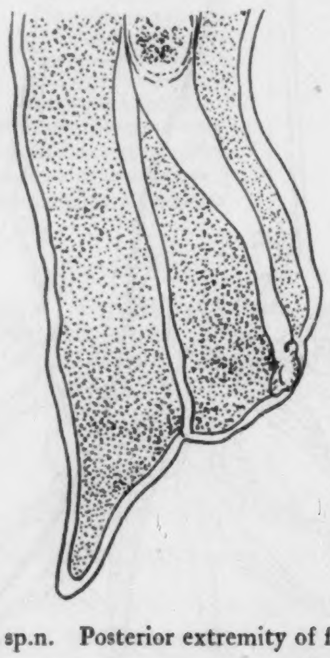

FIG. 7. *Cylicostomum iblei*, sp.n. Posterior extremity of female, lateral view. × 90.

The genital cone and appendages are, in some respects, similar to those of *C. ratzii*.

C. ihlei is, owing to its peculiarities in the structure of the mouth capsule, particularly of the external and internal leaf-crown, very closely related to *C. ratzii*, but may be distinguished from this species by the size and shape of the submedian head-papillae, by the absence of a dorsal gutter, and in general by the entirely different shape and structure of the posterior extremity of the female. The close relationship of *C. ihlei* with *C. ratzii* is seen also in the rather similar structure of the genital cone and appendages in the two forms.

In the character of the mouth capsule *C. ihlei* closely resembles *C. euproctus* (Boulenger, 1917), but it can be distinguished from this species by the differences in the termination of the body in both sexes.

Cylicostomum prionodes, sp. n.

Three specimens (females) of this new form, belonging to the medium-sized cylicostomes, were found in the caecum. The worms

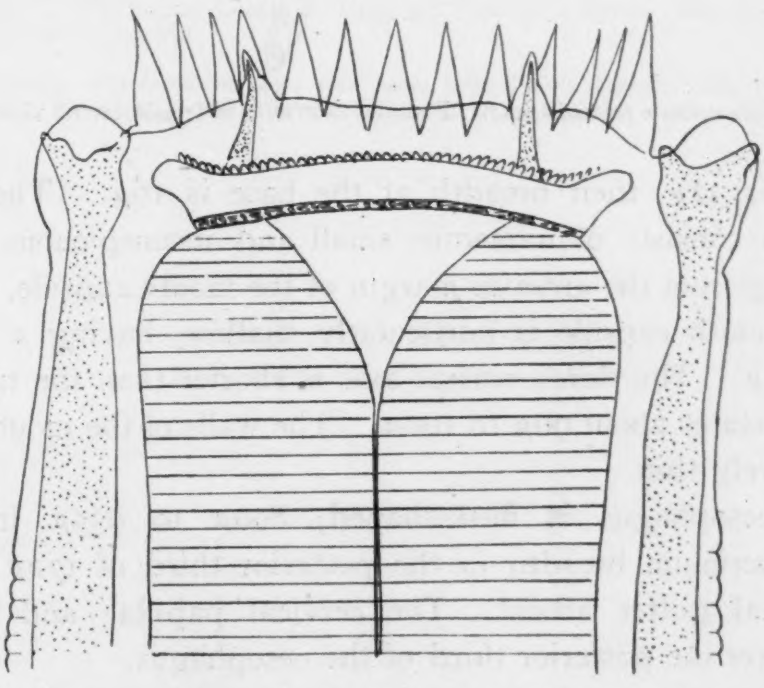

FIG. 8. *Cylicostomum prionodes*, sp.n. Anterior extremity, dorsal view. × 345.

were from 10 mm. to 11·5 mm., with a maximum body breadth of 520 μ.

Head continuous with the body. The mouth collar is distinctly marked from the rest of the skin, especially when seen laterally. The submedian head-papillae are pointed, rather long and prominent; the lateral papillae are rounded and not projecting. Mouth opening oval and very spacious.

The elements of the external leaf-crown resemble those of the teeth of a saw, numbering about twenty-four to twenty-six, arising from the posterior margin of the mouth collar. The length of these

FIG. 9. *Cylicostomum prionodes*, sp.n. Posterior extremity of female, lateral view. × 90.

elements is 32μ, their breadth at the base is 16μ. The internal leaf-crown consists of numerous small and inconspicuous elements originating from the anterior margin of the mouth capsule.

The mouth capsule is particularly shallow, having a depth of 13μ to 14μ. The dorso-ventral axis is shorter than the transverse, which measures about 90μ to 100μ. The walls of the mouth capsule are relatively thin.

The oesophagus is flask-shaped, 800μ to 935μ in length, with a maximum breadth in the posterior third of 172μ. Dorsal oesophageal gutter absent. The cervical papillae and excretory pore lie over the posterior third of the oesophagus.

The posterior extremity of female diminishes gradually up to anus; the tail is distinctly marked off from the body, and measures 125μ in length. The vulva is situated about 108μ from the anus.

Owing to lack of sufficient material, it is difficult to group

C. prionodes with any other species of the genus *Cylicostomum*. I believe, however, that this species is, in certain respects, allied to *C. brevicapsulatum* (Ihle, 1920), but is distinguishable from the latter by the shape of the mouth opening and of the mouth collar, and especially by the structure of the external and internal leaf-crowns.

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[illegible] with [illegible] species of the genus [illegible]. I believe, however, that this specimen, in certain respects, allied to [illegible] (Hale?) [illegible] distinguishable from the latter by the shape of the mouth opening and of the [illegible], and especially by the structure of the ventral and [illegible] [illegible].

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OBSERVATIONS ON THE CERATOPOGONINE MIDGES OF THE GOLD COAST WITH DESCRIPTIONS OF NEW SPECIES

PART III.

BY

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(*Received for publication* 1 *December*, 1920)

SYSTEMATIC ACCOUNT—*continued*

Genus *PRIONOGNATHUS*,* nov.

Eyes bare. Proboscis not longer than the head, chitinised, the mandibles (♀) serrated on both sides distally. Palpi composed of five segments, the second to fifth sub-equal in length, the fifth somewhat pyriform with an apical whorl of stout hairs; third segment not inflated, the sensory hairs long, arising from a very shallow, distal depression. Antennae of the female pilose, the five terminal segments somewhat elongate; of the male plumose, the three terminal segments elongate. Thorax arched anteriorly, not projecting over the head; anterior thoracic pits minute, posterior and post-scutellar pits absent. Wings entirely devoid of erect microscopic setae, but with sparsely arranged short, spine-like, decumbent hairs on the distal portion; anterior cross-vein short, first and third veins separate distally enclosing a single cell or interspace. Femora unarmed in the female, sometimes spinose in the male; first tarsal segment of middle leg distinctly longer and narrower than those of the fore and hind legs, of hind legs bearing, ventro-laterally, a

* πριων, saw and γναθος, jaw.

double comb of short, strong bristles; fourth tarsal segment of all legs obchordate. Claws of female (at least one) very large, simple, equal or unequal; claws of male small, equal, bifid at the tips. Empodium minute, bristle-like.

Genotype *P. marmoratus*, sp. n.

This genus is allied to *Culicoides*, Latr., which it resembles somewhat closely in general morphology; but it is apparently more nearly related to *Alluaudomyia*, Kieff. (1913), and, indeed, is only separated therefrom by reason of the nature of the wings. In *Prionognathus* the wing surface is completely devoid of microtrichia (microscopic pubescence), while in the only known—and therefore type—species of *Alluaudomyia* (*A. imparunguis*, Kieff.), Kieffer states that the wings are covered with 'microscopic hairs and longitudinal ranges of longer hairs, some scattered longer hairs distally.' Long hairs (somewhat spine-like) are present on the distal portions of the wings of *Prionognathus*, but, although rather different in form from those observed in other genera, special importance cannot be attached to them since the distribution and density of arrangement of such hairs may show considerable specific variation—for example, in *Culicoides* the longer wing hairs may be numerous, sparse, or very scanty and confined to the distal margin. The presence or absence of microtrichia, however, appears to be a character of distinctly greater value; when such are present they are, so far as we have observed, distributed evenly over the wing field and specifically invariable.

Prionognathus is probably not confined to the tropics since the species described from Germany by Winnertz (1852) as *Ceratopogon splendidus* appears to be congeneric with the African specimens. Kieffer (1919) places this midge in *Culicoides*, but, so far as we are aware, it has not been captured since Winnertz's time, and the characters and figure of the wing (as well as the striking general facies of the species) given by the latter author seem to justify its inclusion in *Prionognathus*.

At present little information regarding the habits of these midges or of their early stages is available. It is probable, however, that the larvae, like those of *Dasyhelea*, are not strictly aquatic since a female of one of the species (*P. pseudomaculipennis*, sp. n.) obtained was reared from rotten wood taken from canoes.

The external morphology of this genus agrees, except as indicated in the generic description given above, with that of *Culicoides*, and, therefore, no detailed account is necessary. In two respects—the mouth-parts and wings—however, the description referred to may be extended.

Mouth-parts (fig. 1): Labium in both sexes, normal, soft and hairy. Labrum in the female, rather strongly chitinised, the proximal two-thirds broad, the distal third tapering to a somewhat pointed apex, fringed on both sides with delicate

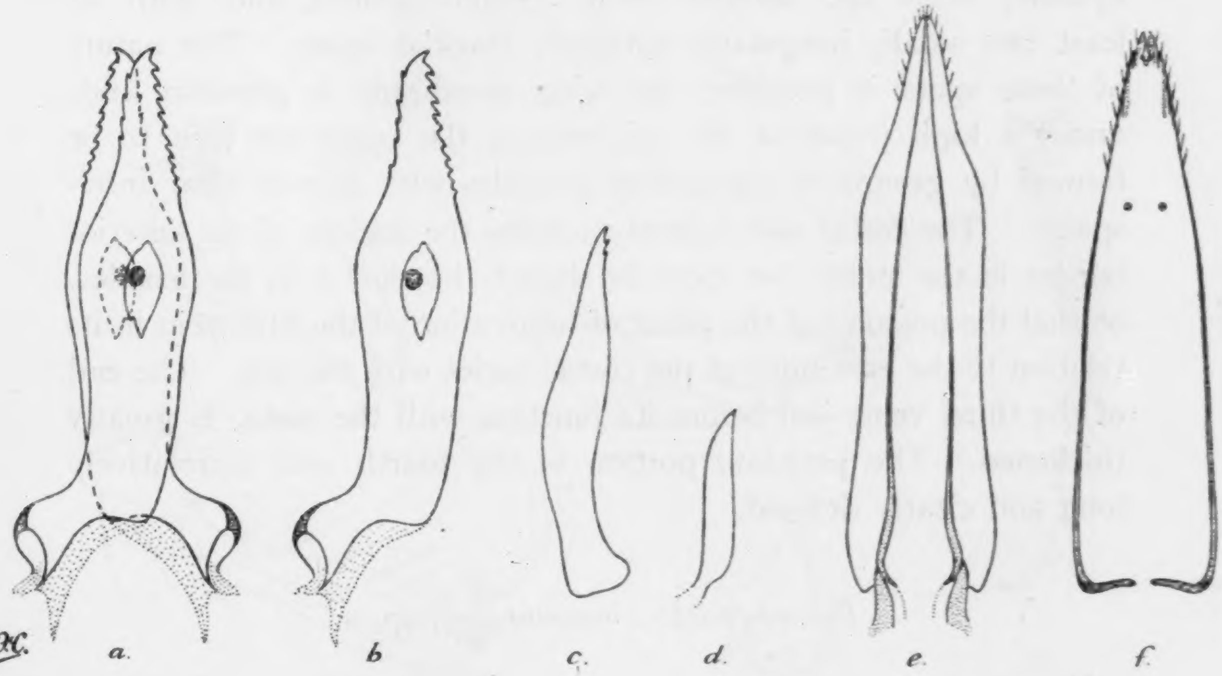

FIG. 1. ***Prionognathus marmoratus***, sp.n. *a*—mandibles (♀), normal position; *b*—mandible (♀); *c*—mandible (♂); *d*—maxilla (♀); *e*—hypopharynx (♀); *f*—labrum (♀). (× 540 circa.)

hair-like processes and armed with two large, terminal, and two pairs of smaller, lateral teeth; in the male, narrower, the distal half attenuated and devoid of teeth, but with longer and more numerous hair-like processes towards the apex. Hypopharynx less chitinised than the labrum, broad, tapering abruptly to a pointed apex or with the distal fourth attenuated and tapering to a narrowly rounded apex; distal hair-like processes apparently absent in some species. Mandibles* in the female, very strongly chitinised (except

* Judging by the arrangement of the mouth-parts in females mounted without pressure, the mandibles normally lie one over the other in the middle line, so that the inner edge of the one projects beyond the outer edge of the other (c.f. fig. 1, *a*). At first sight, therefore, a single, densely chitinised, median structure, armed with powerful recurved lateral teeth on the distal third, appears to be present.

near the centre where there is an oval, thinly chitinised area), broad, the distal third narrower, slightly tapering and armed on both sides with teeth—eleven on the inner edge, strong and, except the terminal one, directed backwards, five on the outer edge, smaller and directed forwards; in the male, smaller, narrower and less chitinised with three small teeth on the inner edge at the tip. Maxillae in both sexes rudimentary, reduced to very short, thinly chitinised, unarmed, blade-like processes.

Wings. In all the species described below the wings are hyaline, with the anterior veins cream-coloured, and with at least two small, irregularly outlined, blackish spots. The nature of these spots is peculiar; the wing membrane is granular and, under a high power of the microscope, the spots are seen to be formed by groups of pigmented granules with minute clear interspaces. The costal vein scarcely reaches the middle of the anterior border in the males, but extends slightly beyond it in the females, so that the position of the point of bifurcation of the fifth vein in its relation to the extremity of the costa, varies with the sex. The end of the third vein, just before its junction with the costa, is greatly thickened. The petiolate portion of the fourth vein is relatively long and clearly defined.

Prionognathus marmoratus, sp. n.

MEASUREMENTS.	Male.	Female.
Length of body*	1·0 mm.	1·3 mm.
Length of wing	0·8 mm.	1·1 mm.
Greatest breadth of wing	0·3 mm.	0·4 mm.

Head dark brown, with brown hairs. Eyes in the female narrowly separate above; in the male rather more widely separate. Clypeus and proboscis dark brown, with scanty brown hairs. Palpi (fig. 2) dark brown, the second to fifth segments sub-equal, the fifth somewhat pyriform, with a distal whorl of about six moderately long, stout, hairs, third segment slender, not dilated, with a shallow, apical, depression from which arises a group of relatively long, knobbed, sensory hairs. Antennae brown, the first

* In all cases taken from anterior margin of thorax to tip of abdomen of specimens mounted in carbolic.

segment darker than the others; segments four to ten in the female, oval to sub-cylindrical, from about two to three times as long as the greatest width; last three segments in the male, elongate, subequal in length, the thirteenth slightly longer than the fifteenth; plume hairs mainly yellowish. *Thorax* pale coloured, marbled with darker markings. Dorsum grey or brownish-grey, becoming somewhat yellowish-brown laterally, with ring-like and crescentic sepia markings, most conspicuous on the antero-lateral portion; sparsely clothed with short brown hairs, and with longer, darker hairs

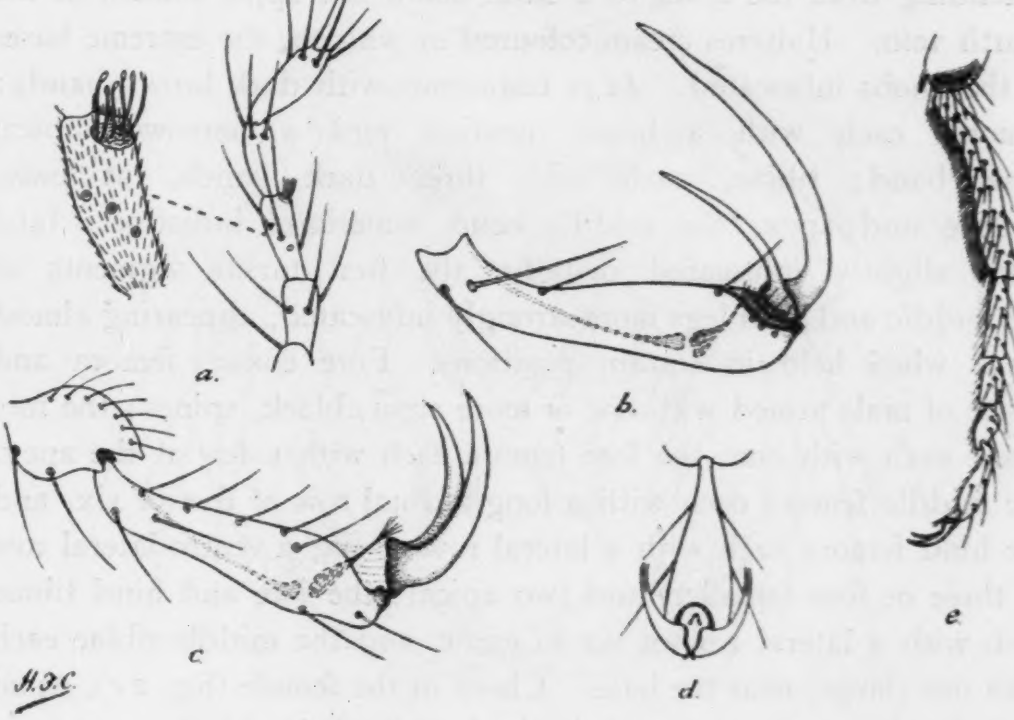

FIG. 2. *a—P. marmoratus*, sp.n., palp (♀); *b—P. maculipennis*, sp.n., fifth tarsal segment and claws of hind leg (♀); *c—P. marmoratus*, fourth and fifth tarsal segments and claws of hind leg (♀); *d—P. marmoratus*, fifth tarsal segment and claws (♂) (ventral view); *e—P. marmoratus*, tarsus of hind leg (♀). (*a* × 220 circa; *b, c, d* × 480; *e* × 125.)

laterally and posteriorly. Pleurae brown. Scutellum yellowish-brown, dark brown medially, bearing, in both sexes, two ventral and two lateral marginal bristles. Post-scutellum dark brown, with two, relatively large, rounded, greyish or yellowish-brown spots anteriorly. *Wings* hyaline with two small, dark brown, spots, one covering the extremities of the costa and first and third veins, the other immediately before, and partially including, the anterior transverse vein. Venation in the female similar to that shown in

fig. 5; venation in the male, resembling that shown in fig. 7, but the tip of the costa less swollen and the radial cell smaller, its length not more than two-thirds the length of its petiole; anterior veins cream-coloured, bearing several, moderately stout, pale brown hairs, the wing membrane between them slightly infuscated. Decumbent hairs sparse, most numerous along the anterior margin from the extremity of the costa to the wing apex, and between the branches of the fourth vein, where they extend backwards almost as far as the middle of the cell; in the male, the decumbent hairs are extremely scanty, being limited almost to a single marginal row, extending from the costa to a little below the upper branch of the fourth vein. Halteres cream-coloured or whitish, the extreme bases of the knobs infuscated. *Legs* testaceous with dark brown bands: femora, each with a broad median and a narrower apical dark band; tibiae, each with three dark bands, at base, middle and apex, the middle band sometimes indistinct; tarsi often slightly infuscated distally, the first tarsal segments of the middle and hind legs more strongly infuscated, appearing almost black when held in certain positions. Fore coxae, femora and tibiae of male armed with one or more stout, black, spines: the fore coxae each with one; the fore femora each with a few at the apex, the middle femora each with a longitudinal row of five or six, and the hind femora each with a lateral row of six, a ventro-lateral row of three or four (smaller) and two apical; the fore and hind tibiae each with a lateral row of six to eight, and the middle tibiae each with one (large) near the base. Claws in the female (fig. 2 *c*), equal and simple, at least two-thirds the length of the fifth segment; in the male (fig. 2 *d*) bifid, shorter, about one-half the length of the fifth segment. *Abdomen* of female very dark brown, almost black, with white, or dusky-white, admedian and lateral markings as shown in fig. 4 *a*. In the male, the admedian pale spots are similar, but those on the second and third segments are larger, almost semi-circular, and less widely separated centrally, while those on the fifth to seventh segments meet in the middle line (at least in some specimens) and form transverse bands—the visible portions of these segments being almost entirely white; the form and arrangement of the lateral markings cannot be definitely observed in the dry, undistended, examples at our disposal. Spermathecae (fig. 9 *a*)

two in number, highly chitinised, sub-spherical (diameter 55μ) each with a long (38μ), chitinous, stalk like process arising below the duct and directed posteriorly; the duct chitinised for a moderately long distance (13μ) at its commencement.

HYPOPYGIUM (fig. 3). Dark brown, highly chitinised. *Ninth segment*: sternite with a shallow ventral excavation; tergite rather short, very slightly chitinised posteriorly, the dorsal surface with six long, strong, hairs, of which four are arranged in a transverse row on the distal third and two are situated laterally immediately above the bases of the forceps, the posterior margin gently rounded

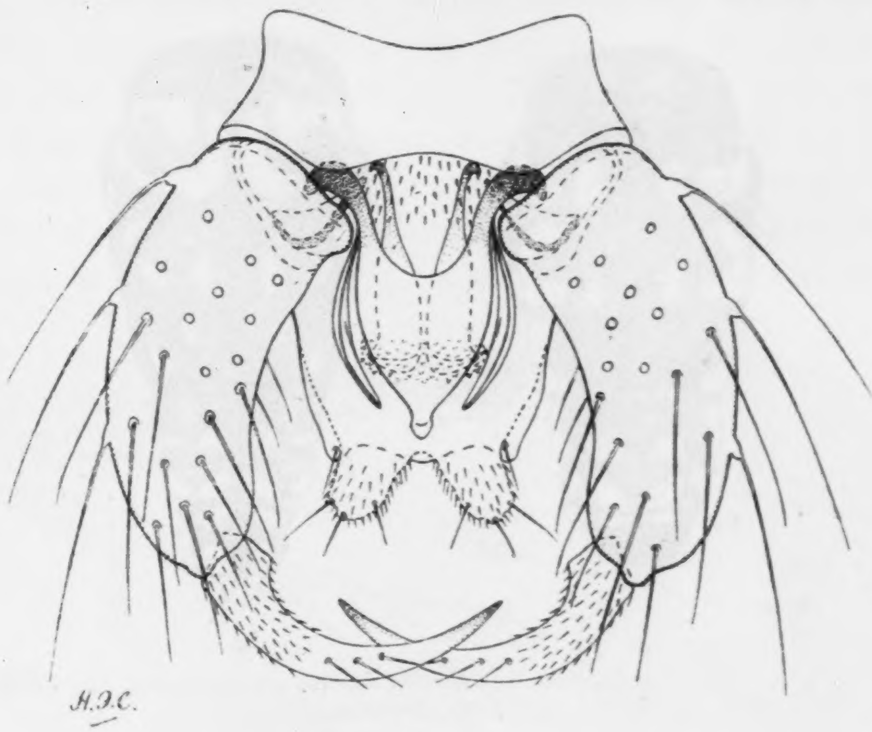

FIG. 3. *Prionognathus marmoratus*, sp.n., male hypopygium, ventral view. (× 400 circa.)

centrally with the lateral finger-like processes reduced to small, rounded flanges, each bearing a short hair, the apical lobe-like processes relatively large. *Forceps*: side-pieces well developed and highly chitinised, rather sparsely clothed with long hairs; clasper long, highly chitinised, hook-like, tapering to a sharp point, the basal portion densely clothed with minute hairs. *Harpes* moderately large, the proximal portions narrowed and highly chitinised, the distal portions broad and flattened, especially at the tips, which are produced slightly on their outer sides. *Aedoeagus* somewhat

shield-shaped, with a chitinous, flange-like process on each side; distal extremity in the form of a short, more or less conical, beak-like process with the apex directed ventrally; limbs highly chitinised basally, with the proximal ends everted; ventral wall chitinised, the anterior half of the membrane connecting it with the ninth sternite studded with spicules.

HABITAT: Accra, Gold Coast; three males and six females, collected in the evening upon the windows of the laboratory, January to March, 1920. Bonny, Nigeria, three females, collected by Dr. H. E. Annett upon windows, 6.30 a.m., May 13th, 1900 (in collection of the Liverpool School of Tropical Medicine).

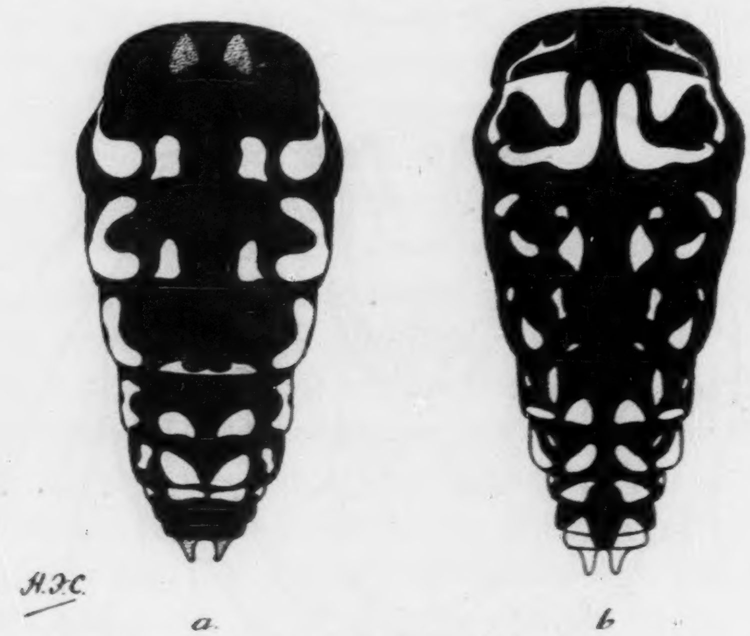

FIG. 4. Abdomens (distended) of females, showing ornamentation. *a*—*P. marmoratus*, sp.n.; *b*—*P. maculipennis*, sp.n. (semi-diagrammatic).

Prionognathus maculipennis, sp. n.

MEASUREMENTS.

Length of body	1·3 mm.
Length of wing	1·1 mm.
Greatest breadth of wing	0·4 mm.

Head greyish-brown with brown hairs. Eyes narrowly separate. Clypeus and proboscis dark brown with brown hairs; mouth-parts similar to those of *P. marmoratus* but the labrum and hypopharynx broader distally, the former bluntly rounded at the apex with three or four closely apposed apical teeth on each side of

the middle line, and seven or eight broader, more rounded, lateral teeth on the distal third, the hair-like processes apparently absent. Palpi brown, the second to fifth segments sub-equal, the fifth swollen distally, with an apical whorl of five or six stout hairs. Antennae brown, the torus darker than the other segments; segments four to ten oval to sub-cylindrical, from about one and one-third to two and one-half times the greatest width. *Thorax* grey or greyish-brown with dark brown more or less V shaped marks covering the anterior pits, and small rounded, dark brown or blackish, spots at the bases of the hairs, which are brown and rather scanty. Pleurae dark brown. Scutellum greyish-brown, dark brown medially, bearing four central bristles—two anterior and two marginal, the latter close together. Post-scutellum dark brown, with two large pale grey, partially contiguous, areas anteriorly. *Wings* hyaline, the membrane between the thickened anterior veins slightly infuscated, with six small, irregularly shaped, blackish spots situated as shown in fig. 5. Decumbent hairs confined to the

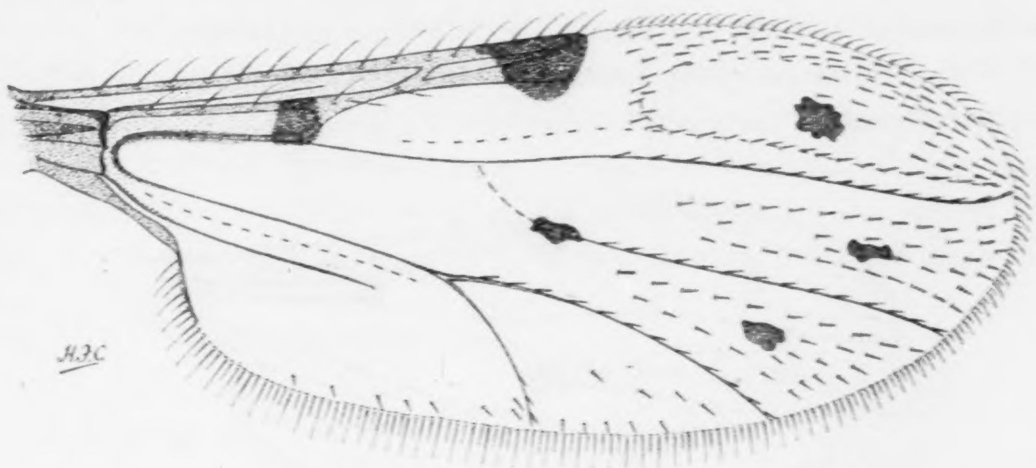

FIG. 5. *P. maculipennis*, sp.n., wing of female. (× 90 circa.)

distal half of the wing, more numerous than in *P. marmoratus*, especially in the anterior region above the upper branch of the fourth vein, and between the branches of the fourth vein, where they extend backwards considerably beyond the middle of the cell. Halteres with greyish-brown knobs, and paler, yellowish-brown, stems. *Legs* brown, the tarsi, except the metatarsi of the hind legs, and bands (most conspicuous on the hind legs) on the femora and tibiae paler, yellowish-brown; femora each with a sub-apical band, the basal thirds of the hind pair also pale ventrally, tibiae

each with two bands, a sub-basal and a sub-apical. Claws (fig. 2 *b*) unequal, one very large, almost as long as the fifth segment, the other small, scarcely half as long as the segment. Abdomen dark brown, with pale grey or greyish-white markings as shown in fig. 4 *b*. Spermathecae (fig. 9 *b*) single, large (54μ by 81μ) highly chitinised, pear-shaped, the posterior third with minute, circular, less highly chitinised areas; the duct chitinised for a short distance at its commencement.

HABITAT: Accra, Gold Coast; a single female taken in the evening upon a window in the laboratory, March 25th, 1920.

Prionognathus pseudomaculipennis, sp. n.

MEASUREMENTS.

Length of body	1·0 mm.
Length of wing	0·85 mm.
Greatest breadth of wing	0·3 mm.

This species greatly resembles *P. maculipennis*, but is considerably smaller and differs also in the following characters.

Head: Eyes narrowly contiguous anteriorly. *Thorax*: Scutellum with two central marginal bristles only. *Wing* (fig. 6) with rather

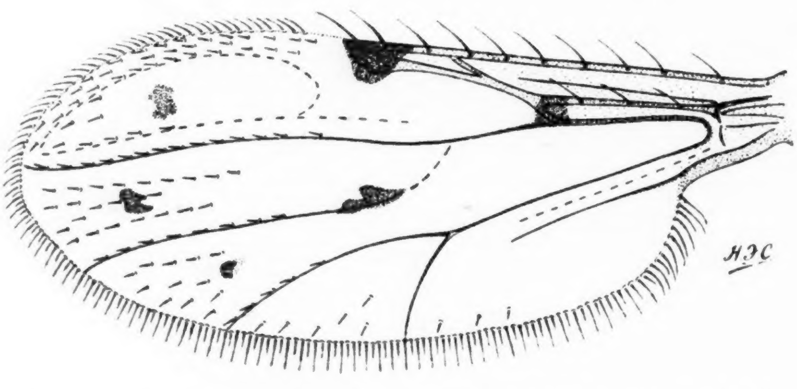

FIG. 6. *P. pseudomaculipennis*, sp.n., wing of female. (× 90 circa.)

less numerous decumbent hairs, those between the branches of the fourth vein not, or scarcely, extending beyond the middle of the cell. *Abdomen* (as seen when undistended) with large yellowish or greyish-yellow pale areas; the admedian pale areas apparently more extensive, especially on segments three and four. Spermathecae (fig. 9 *c*) single, highly chitinised, sub-spherical (diameter 46μ); the chitinised portion of the duct short and broad.

HABITAT: Accra, Gold Coast; one female taken in the evening upon a window in the laboratory, February, 1920. Oblogo, Gold Coast; one female reared from rotten wood from canoes, May, 1920.

Prionognathus maculithorax, sp. n.

MEASUREMENTS.

Length of body	1·1 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·3 mm.

Head brown. Eyes separate; the space between them wedge-shaped, broadest at the vertex. Clypeus and proboscis brown, with brown hairs. Palpi brown, the second to fifth segments sub-equal, the fifth swollen distally with an apical whorl of relatively stout hairs. Antennae greyish-brown, the torus darker than the other segments; terminal segments (thirteen to fifteen) elongate, the thirteenth distinctly larger than the others. *Thorax* pale greyish-brown, with small dark spots; the markings very similar to those of the two preceding species (*P. maculipennis* and *P. pseudo-maculipennis*), sparsely clothed with brown hairs. Pleurae and post-scutellum brown. Scutellum pale brown with two central marginal bristles. *Wings* hyaline with small blackish spots as shown in fig. 7. Decumbent hairs scanty, almost confined to the anterior

FIG. 7. *P. maculithorax*, sp.n., wing of male. (× 90 circa.)

and distal margins. Halteres with brown knobs. *Legs* brown, with paler bands as in *P. maculipennis*; femora and tibiae without spines. Claws bifid, equal, about one-half the length of the fifth tarsal segment. *Abdomen* dark brown, with pale grey markings

somewhat similar (so far as can be determined from the single specimen obtained) to those in *P. maculipennis*.

HYPOPYGIUM (fig. 8). *Ninth segment*: tergite rather short, the posterior margin slightly curved and bearing, on each side, a long finger-like process; sternite relatively large, produced posteriorly, on each side of the middle line, into a rounded lobe covered with minute hairs. *Forceps*: side-pieces moderately chitinised, dark and hairy; claspers less chitinised, the basal third broad, pubescent; the distal extremity pointed, bearing a few small hairs. *Harpes* large, strongly chitinised; proximal portion directed laterally, forming almost a right angle with the distal portion; the latter broad

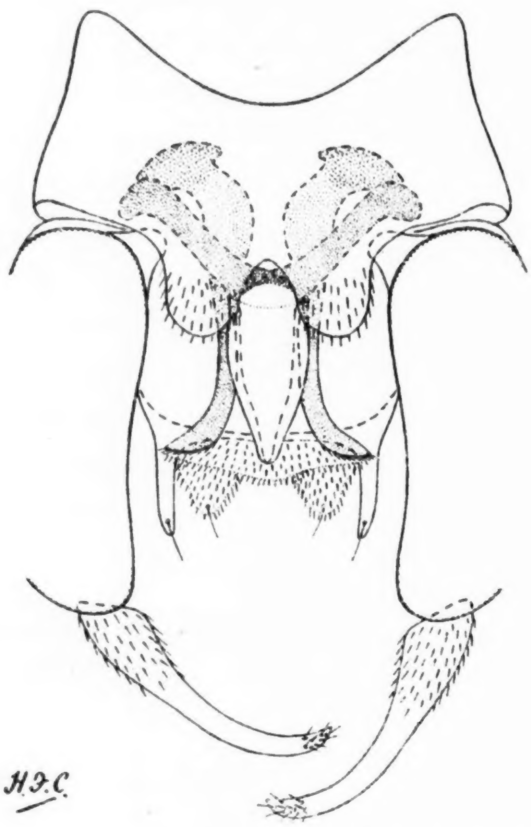

FIG 8. *Prionognathus maculithorax*, sp.n., male hypopygium, ventral view. (× 400 circa.)

at the base and curving inwards for a short distance, then extending almost directly backwards (becoming narrower near the middle) and terminating in a slightly expanded, outwardly directed extremity, the posterior margin of which bears a number of minute hairs. *Aedoeagus* large; the anterior portion (limbs) very strongly chitinised, and occupying a more ventral position than the rest, the

posterior portion relatively broad, but narrowing in the distal fourth and ending in a bluntly rounded apex.

HABITAT: Accra, Gold Coast; one male taken in the evening upon a window of the laboratory, January, 1920.

Genus *ATRICHOPOGON*, Kieff.

Ceratopogon, Meig. (pro parte). Illiger's Mag. Ins. Vol. II, 1803.
Atrichopogon, Kieff. Ann. Soc. Scient. Brux. Vol. XXX, 1906.
Ceratopogon, Mall. (nec. (Meig.), Edw.). Bull. Ill. Sta. Lab. Nat. Hist. Vol. X. Art. vi, p. 304, 1915.

Malloch's restriction of the name *Ceratopogon* to the group of species exemplified by *fusculus*, Coq. (the species first cited by him) cannot be maintained. *C. communis*, Meig., the accepted type of *Ceratopogon*, was thought by Johannsen (1908) and others, including Malloch, to belong to the same group as *exilis*, Coq., which by Coquillet's (1910) designation is the type of *Atrichopogon*, Kieff. The adoption of this use of the name *Ceratopogon*, *i.e.*, replacing *Atrichopogon*, seemed probable (even although Kieffer (1917 and 1919), by unjustifiably applying *Ceratopogon* to *Forcipomyia*, rejected it), until Edwards (1920) showed conclusively that *C. communis* not only differed in structure from the *exilis* type, but that it did not belong to any of Kieffer's genera.

The genus *Atrichopogon* includes those midges in which the eyes are bare, the metatarsi of the hind legs considerably longer than the second segments, the empodia well-developed, and the wings bear long hairs (usually somewhat scanty and confined to the distal portion) and possess a long and narrow second radial cell which extends to the distal third. Two females, of a single species, only were obtained in this investigation, and no detailed account of the external morphology can therefore be given. As, apparently, no attention has been paid to the mouth-parts of the females of this genus, a short description of those of our specimens may be of interest.

Mouth-parts. The proboscis of the female is slightly shorter than the height of the head. The labium is soft and similar to that of *Culicoides* (*vide* Carter, Ingram and Macfie, 1920), but possesses longer hairs distally. The labrum is relatively broad, but the

distal third tapers to a pointed, or very narrowly rounded, apex, and is fringed on each side with numerous, short, hair-like processes. The hypopharynx is less strongly chitinised than the labrum; the proximal two-thirds are broad, the distal third attenuated, scoop-like, and without teeth or lateral processes. The mandibles are large, pointed, strongly chitinised structures, each with from eighteen to twenty teeth on the inner distal margin; the ten or twelve anterior teeth are larger and stronger than the others. The maxillae are much less strongly developed than the mandibles; they are not more than three-quarters the length of the latter, are slightly chitinised and obliquely truncate distally, the inner distal edge bearing eight inconspicuous, somewhat rounded, teeth.

Atrichopogon xanthoaspidium, sp. n.

MEASUREMENTS.

Length of body	1·7 mm.
Length of wing	1·3 mm.
Greatest breadth of wing	0·5 mm.

Head brown, clothed with brown hairs. Eyes broadly contiguous above. Clypeus, palpi and proboscis dark brown, with dark brown hairs, first palpal segment small but distinct, second, fourth and fifth segments sub-equal, third segment at least one and one-half times the length of any of the others, slightly inflated at the distal third where a small, but deep, sensory cup exists. Antennae dark brown, with slightly paler hairs; segments four to ten short and broad, the tenth sub-spherical, the others broader than long, the length varying from half to two-thirds the breadth; last five segments (eleven to fifteen) elongate, from two and a half to three and a half times as long as broad, their combined lengths almost twice those of segments three to ten, the fifteenth terminating in a small stylet. *Thorax* dark brown, pruinose, showing indistinct yellowish-brown, sub-circular, anterior areas when held in certain positions; clothed with short golden-brown hairs. Pleurae dark brown. Scutellum yellowish, bearing two sub-median and two lateral bristles and several (fifteen to twenty) short hairs. Post-scutellum dark brown. *Wings* clear, unspotted, the anterior veins

yellowish-brown; venation and arrangement of decumbent hairs as in fig. 10. Halteres with white knobs and infuscated stems. *Legs* almost uniformly yellowish-brown, but with indications of darker knee-spots, and with the tarsal segments slightly infuscated. Claws equal, about half the length of the fifth tarsal segment, each with a very minute, sub-apical, tooth. Empodium well-developed, at least as long as the claws. *Abdomen* brown, rather darker than

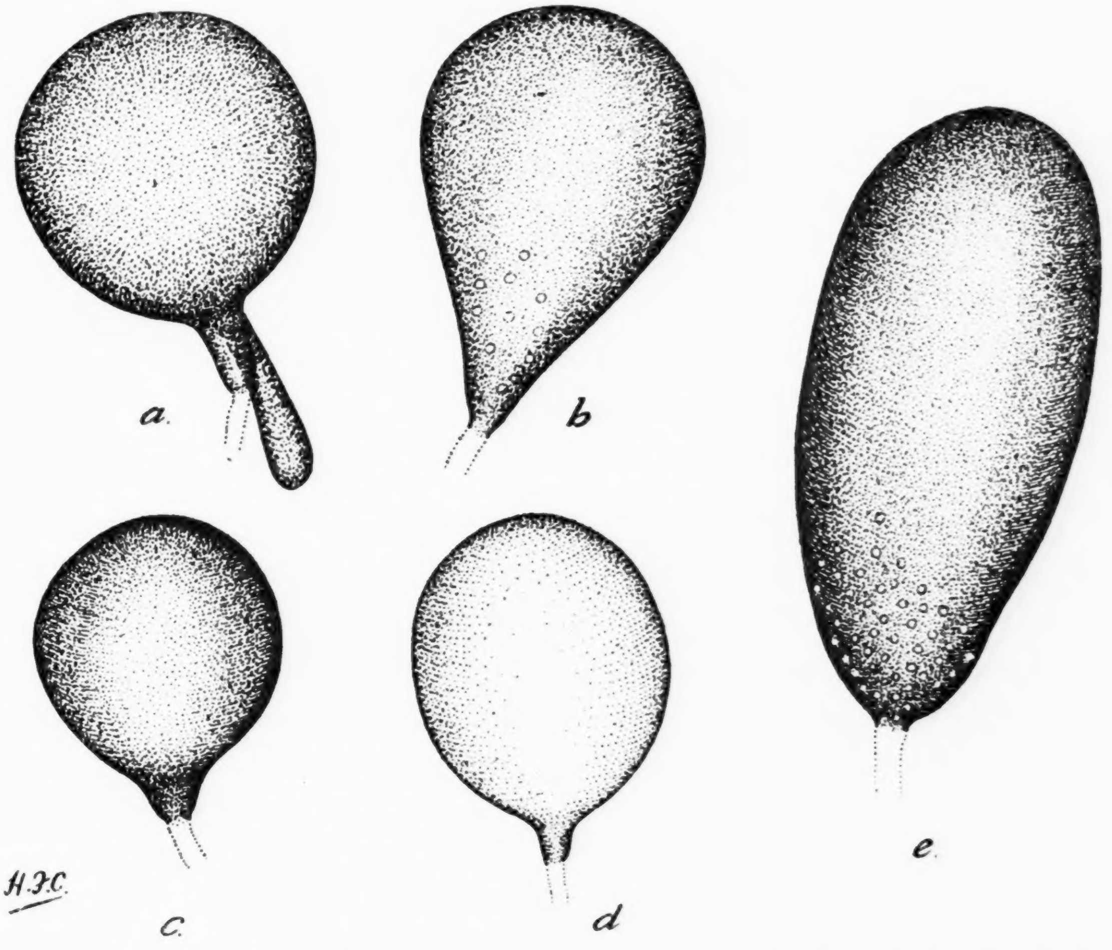

FIG. 9. Spermathecae of: *a—Prionognathus marmoratus*, sp.n. (one only shown); *b—P. maculipennis*, sp.n.; *c—P. pseudomaculipennis*, sp.n.; *d—Stilobezzia spirogyrae*, sp.n.; *e—Atrichopogon xanthoaspidum*, sp.n. (× 540 circa.)

the thorax; ventral surface paler. Spermathecae (fig. 9 *e*) single, large (length 120μ, greatest breadth 49μ), sac-like, heavily chitinised, the posterior third narrower, with the chitin strongly pitted, appearing as if covered with minute white dots; no portion of the duct chitinised.

HABITAT: Accra, Gold Coast. Two females, collected in the evening upon a window in the laboratory; May, 1920.

This species is the third of the genus *Atrichopogon* to be described from the Ethiopian region; the others are *A. anemotis*, Kieff., and *A. tropicus*, Kieff., both of which were described by Kieffer in 1913. From *A. anemotis*, of which the male only is known, it apparently differs in size, colouration of the abdomen, and

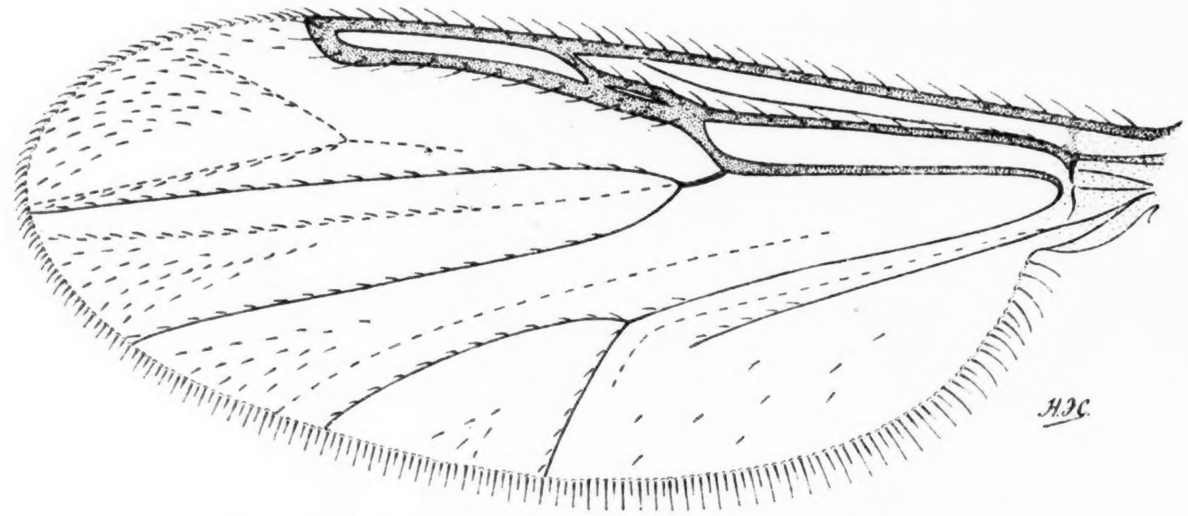

FIG. 10. *Atrichopogon xanthoaspidium*, sp.n., wing of female. (× 90 circa.)

wing venation, and from *A. tropicus* in venation and arrangement of the larger wing hairs. Judging by Kieffer's figure, the petiolate portion of the fourth vein in *A. anemotis* is almost twice the length of that of *A. xanthoaspidium*, while in *A. tropicus* bifurcation takes place at the cross vein.

Genus *STILOBEZZIA*, Kieff.

Stilobezzia, Kieff. Rec. Ind. Mus. Vol. VI, p. 118, 1911.
Hartomyia, Mall. Bull. Ill. Sta. Lab. Vol. X. Art. vi, p.339, 1915.

This genus was erected by Kieffer for species of *Palpomyia* and *Johannsenomyia* in which the fork of the fourth longitudinal vein is petiolate. The chief generic characters, according to this author (1919) are—wings glabrous, the first and third veins forming two radial cells of which the second is longer than the first, the fourth vein petiolate, the fourth tarsal segment cordiform in both sexes, and the claws long, simple and very unequal in the female, short and equal in the male.

Kieffer's statement that the wings are glabrous is evidently not

intended to include microtrichia; these cover the whole surface, and are mentioned by him in his description of the type species (*S. festiva*). In the species described below the claws of the female are referred to as 'single with a large basal tooth,' as actually they are; but this statement does not imply any disagreement with the generic definition, since it is abundantly clear that, in our species, fusion has taken place and that the basal tooth represents the smaller claw.*

The larvae and pupae greatly resemble those of *Culicoides*. The larvae are vermiform with relatively short, strongly chitinised heads, and feebly-developed body hairs; the hypopharynx, however, is much more complex in structure, and is produced posteriorly into a relatively large hemispherical sclerite. The pupae differ from *Culicoides* (but agree with *Dasyhelea*) mainly in the greater size of the second abdominal segment.

Stilobezzia spirogyrae, sp. n.

Measurements.	Male.	Female.
Length of body	2·4 mm.	2·0 mm.
Length of wing	1·6 mm.	1·7 mm.
Greatest breadth of wing	0·5 mm.	0·6 mm.

Head: occiput green with brown hairs. Eyes, in the female contiguous, in the male narrowly separate. Clypeus and proboscis brown, with brown hairs. Palpi dark brown, slender, the first segment minute, the second and fourth short, the third and fifth considerably longer; third segment slightly inflated with a shallow, anterior depression from which arise several long, slender, sensory hairs. *Antennae*: in the female yellowish-brown, the torus darker with brown hairs, third to tenth segments sub-cylindrical, the third about four times as long as wide, the fourth to tenth from two and one-half to three and one-half times as long as wide; segments eleven to fifteen very slender, cylindrical from about seven to eighteen times as long as wide, increasing progressively in length to the last, which is about one and a half times as long as any of the others. In the male, rather paler brown with dark brown plumes; segments three

* In this connection it is interesting to note that with those species of *Prionognathus* in which the claws are unequal in size, the base of the smaller one rests upon, and appears to arise from, that of the larger.

to twelve short and broad, segments thirteen to fifteen greatly elongated, the fifteenth excessively long and thin. *Thorax*: dorsum in the female, shining greyish-green, becoming somewhat greenish pruinose anteriorly, with conspicuous sepia-coloured markings as follows: a broad median stripe extending from the anterior margin almost to the centre, two admedian stripes, broad on the anterior third, linear throughout the rest of their course, extending from the anterior margin to the scutellum, and two short lateral stripes each of which, commencing near the centre, extends anteriorly and then curves sharply inwards to join the admedian stripe near the middle of the broad portion; clothed with rather stout, brown hairs or bristles on the disc (arranged in median and admedian longitudinal rows) and sides. In the male the colouration of the dorsum resembles that of the female, but is more pruinose, especially laterally and in the region of the posterior depression. Pleurae greenish-pruinose, with a relatively large, dark brown patch over the coxae of the middle legs. Scutellum with seven strong brown bristles—one central marginal (usually absent in the male), two central sub-marginal, two central median and two lateral. Post-scutellum olive green. *Wings* pale grey, strongly irridescent, with dark brown markings and venation as shown in fig. 11. Halteres pale, the distal half of

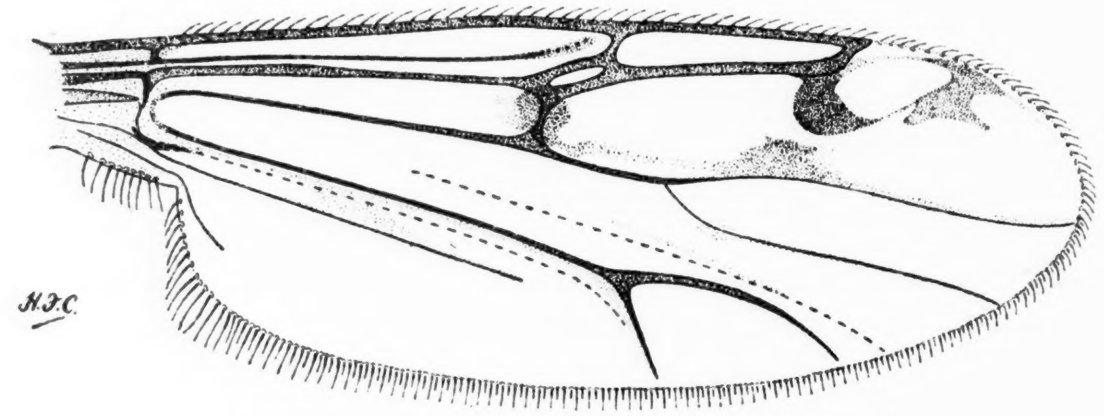

FIG. 11. *S. spirogyrae*, sp.n., wing of female. (× 65 circa.)

the knobs dark brown. *Legs* (fig. 13) in both sexes pale olive green with olive brown markings; some of the tarsal segments armed with conspicuous, stout, black spines, and the first and second tarsal segments of all the legs bearing rows of small spines. Fore femora pale, slightly darker at the bases, the distal half of the middle femora and the whole of the hind femora (except the extreme apices)

infuscated. Tibiae similar to the femora but with the distal extremities dark. Tarsi with the last two segments slightly darkened; in both sexes, the small spines on the first and second segments of the fore and middle legs are arranged in a single ventral, or ventro-lateral, longitudinal row, while on the hind legs there are two ventro-lateral rows on each of these segments and, in addition, on the first segment a lateral row extending from the base to about the middle; five large, black spines are present on the middle tarsi--one at the base of the first segment and a pair at the apices of the first and second segments—and, in the female, an additional pair occurs on the fifth segment of the fore and middle legs. Claws in the female single, almost as long as the fifth tarsal segment, with a large basal tooth; in the male less than half the length of the fifth segment, equal, bifid at the tips. *Abdomen* pale green with dark brown markings, which are most conspicuous on the posterior segments; clothed with brown hairs and bearing, near the centre of each of the second to fifth tergites, a tuft of relatively large, black bristles. Spermathecae (fig. 9*d*) two in number, slightly chitinised, sub-spherical (57μ by 48μ); the commencement of the duct chitinised for a short distance.

HYPOPYGIUM (fig. 12). *Ninth segment*: sternite with a relatively shallow ventral excavation; tergite short, the posterior margin irregularly rounded without lateral finger-like processes. *Forceps*: side pieces relatively large, each with a broad, inwardly projecting basal process; the proximal portion very broad, narrowing sharply near the middle, the distal portion tapering gradually to a broadly rounded apex. Claspers stout, terminating in a large, stout, blunt process; clothed with minute hairs, intermixed with several strong hairs on the basal half and three or four delicate hairs near the apex. *Harpes* slender, very heavily chitinised; the proximal portion short (about one-fourth the entire length) expanding anteriorly, the distal portion broad anteriorly, gradually tapering and directed inwards and downwards to about the apical third, then extending in an antero-posterior direction to the apex, which is swollen and hooked. *Aedoeagus* somewhat V-shaped, less heavily chitinised than the harpes, with the distal extremity expanded into a thinly chitinised, flange-like structure and directed dorsally at almost a right angle to the plane of the ventral wall; in ventral view the distal portion

frequently appears to be divided centrally into two separate flanges. Ventral wall membranous, continuous with the membrane connecting it with the ninth segment; spicules absent.

PUPA. Length 2·9 mm. to 3·4 mm., average of four 3·2 mm. *Respiratory trumpets* as shown in fig. 13 *g*, length 0·35 mm.; they are rather slender, dark-tipped structures, sharply constricted at the base and slightly narrowed near the distal fourth; the main tracheal

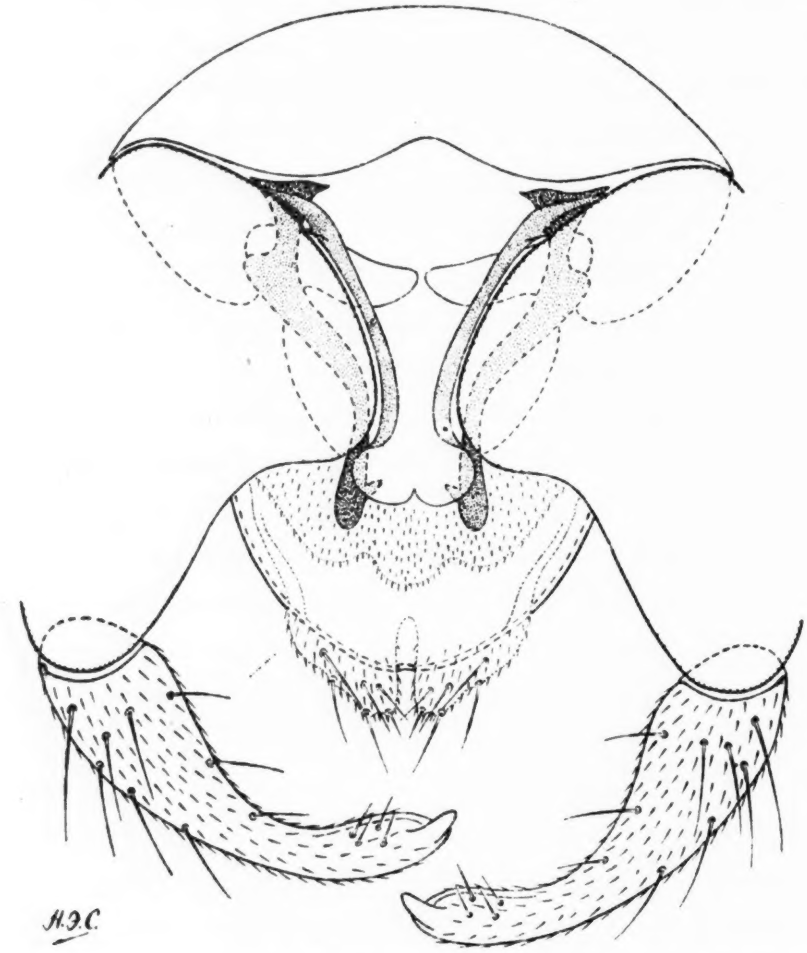

FIG. 12. *S. spirogyrae*, sp.n., male hypopygium, ventral view. (× 400 circa.)

trunk is relatively broad, devoid of lateral branches, and terminates in a number (about fifteen) of short, blunt processes which lead to the surface and are arranged as indicated in the figure. *Cephalothorax* somewhat infuscated dorsally. Anterior marginal tubercle, large, conical, bearing a short, stout spine; anterior dorsal, small with a short spine and a hair; anterior dorso-median,* very small,

* This tubercle is not present in *Culicoides*; it is situated on the inner side and just above the base of the trumpets.

bearing a short spine and a hair; anterior dorso-lateral, small, bearing a long, terminal hair, and a short, lateral bristle; ventro-lateral, represented by three small hairs; ventro-median, absent. Dorsal tubercles reduced to two pairs of minute bristles or hairs.

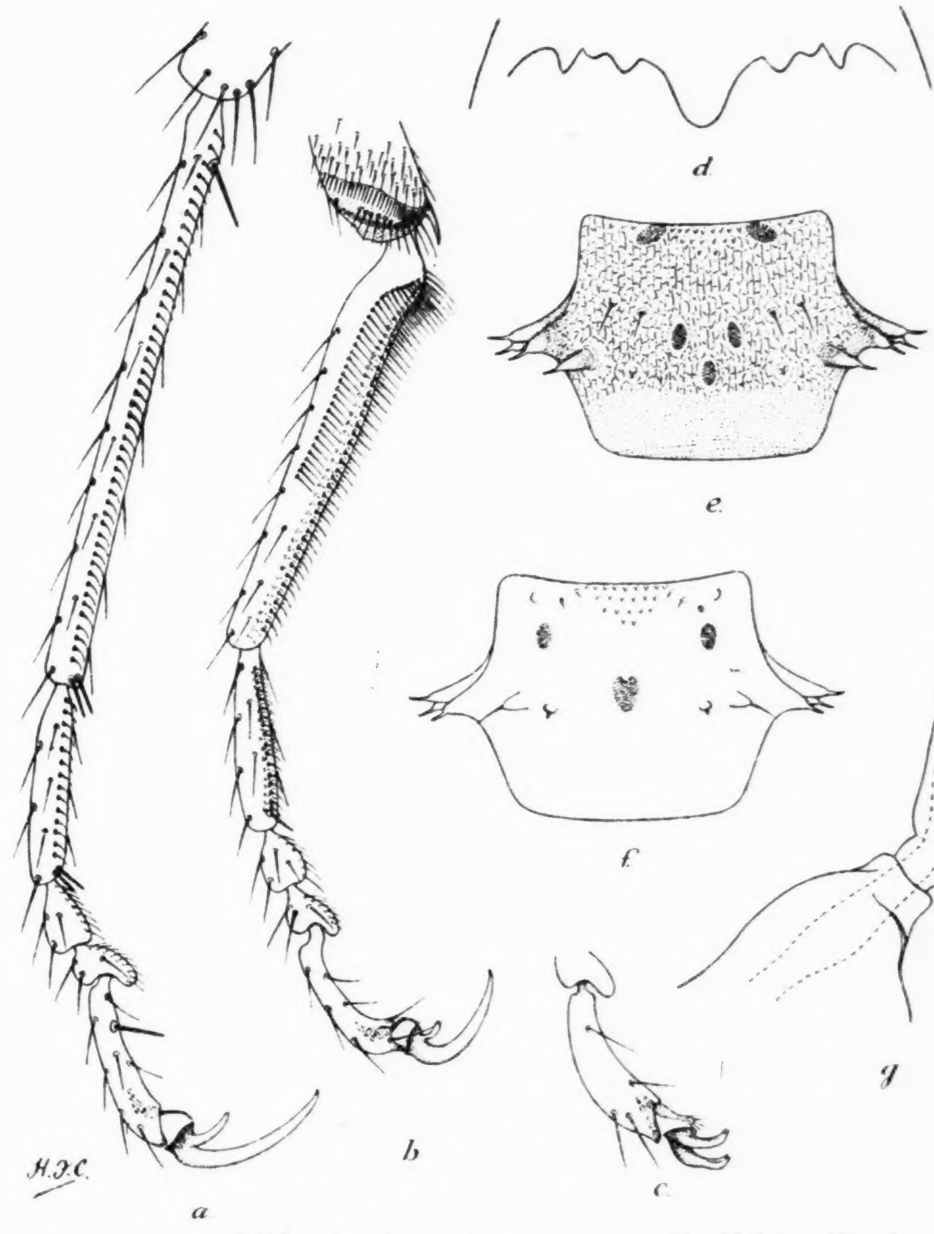

FIG. 13. *Stilobezzia spirogyrae*, sp.n. *a*—tarsus of middle leg (♀); *b*—tarsus of hind leg (♀); *c*—fifth tarsal segment and claws of middle leg (♂); *d*—teeth on posterior margin of hypopharyngeal sclerite of larva; *e*—fifth abdominal segment of pupa (dorsal view); *f*—fifth abdominal segment of pupa (ventral view—surface markings, other than pigmented areas, omitted); *g*—respiratory trumpet of pupa. (*a* and *b* × 125 circa; *c* × 260; *d* × 1050; *e* and *f* × 80; *g* × 220.)

Posterior dorsal tubercle small, bearing a short hair. *Abdomen*: first segment small and narrow, second segment large and broad, the others decreasing progressively in breadth towards the apex;

integument reticulated except on small areas (shagreened) at the bases of the last four or five segments, on the distal portions of the segments, and on small oval pigmented areas situated on each segment as shown in fig. 13 *e* and *f*. Anal segment with acutely pointed, widely divergent (directed almost at a right angle to the axis of the body), dark-tipped processes which are almost two-thirds the length of the segment. Dorsal tubercles: antero-submarginal, small, each bearing a short hair; postero-marginal,* the inner very small (larger on the eighth segment), bearing a minute hair, the outer large, with a short, stout spine. Ventro-lateral tubercles: antero-submarginal absent; postero-marginal, very large, each bearing a short, stout spine. Ventral tubercles: the inner minute, bearing a minute spine, the outer large, bearing a long hair.

LARVA. Length 4·5 mm. to 5·6 mm., average of five 5·1 mm. Greatest breadth 0·27 mm. to 0·37 mm., average of four 0·3 mm. *Head*: yellowish-brown, length about 0·3 mm., greatest breadth 0·2 mm. Median dorsal plate (clypeus) broad posteriorly. Eyes black, bilobed or reniform, the anterior portion small. Hairs very small, apparently arranged as follows: on the dorsal surface, one pair anterior admedian, one pair anterior dorso-lateral, two pairs central dorso-lateral, two pairs posterior dorso-lateral, and two pairs posterior admedian; on the ventral surface, two pairs anterior admedian, three central ventro-lateral, and one pair sub-central, admedian. Mental plate delicate, relatively short and broad, apparently without teeth. Hypopharynx strongly chitinised, the posterior margin, or what appears to correspond with the posterior margin in *Culicoides*, armed with a large, rounded, central tooth, and three small teeth or processes on each side (*c.f.* fig. 13 *d*). Mandibles simple, hook-like. *Body* with scanty and very minute hairs; those on the distal portion of the anal segment larger and stronger and arranged in six pairs, of which two pairs are smaller and more delicate than the others.

HABITAT: Oblogo, one male and one female bred from pupae obtained from a washing place in the river; Nsawam, four males

* The number and arrangement of the postero-marginal tubercles differ from those of *Culicoides*. In *Stilobezzia* seven only are present—two dorsal, three ventro-lateral and two ventral; they are situated near the middle transverse line and form an almost continuous semi-circular lateral band—the innermost of the dorsal and ventral tubercles being situated a considerable distance from the middle line.

and three females reared from larvae and pupae taken from a swamp, 26th May, 1920.

This strikingly coloured midge is apparently the first species of *Stilobezzia* to be described from Tropical Africa. The larvae and pupae of the Nsawam examples, referred to above, were associated with a species of *Spirogyra*. A specimen of this alga was very kindly examined for us by Miss Nellie Carter, of Birmingham University, who wrote as follows:—'The alga is a species of *Spirogyra*, Link, but it is sterile, and in the absence of ripe zygospores it is quite impossible to name the species. There is also amongst it a little *Oscillataria tenuis*, Ag. (*Cyanophyceae*), and a quantity of the filamentous diatom *Fragillaria virescens*, Ralf, but the *Spirogyra* is present in by far the greatest bulk.'

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MUSCA INFERIOR, Stein, TYPE OF A NEW GENUS OF PHILAEMATOMYINE FLIES *(DIPTERA)*

BY

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Turin, Italy

(Received for publication 22 November, 1920)

In 1909, Stein, the well-known Monographer of the Anthomyidae of the world, described a *Musca inferior* from Java, pointing out as the main characters, the greater size, yellowish colour of palpi, separated eyes of the male, presence of only a single pair of well-developed dorso-ventral macrochaetae, and the lineate pattern of the abdomen. These characters are sufficient for the immediate recognition of the fly.

In 1912, Patton and Cragg published in these *Annals* a short preliminary description of an Indian fly under the name of *Philaematomyia gurnei*, of which, later in the same year, they gave a detailed description with beautiful figures.

In 1916, in my second paper on the Philippine *Diptera*, I established the synonymy of the two above-named species, leaving them in the genus *Philaematomyia*, Austen, under the name of *Ph. inferior*, Stein, and establishing their presence in the Philippines.

Subsequently, in 1918, two papers appeared with more notices on this same fly, but without referring to the synonymy given by me. The first of these papers is by Stein, who, recording the species, under the generic name of *Musca* from Formosa, points out its affinity with *Crassirostris insignis* (the type species of the genus *Philaematomyia*), and recognises that the two species must be placed in one new genus; on this occasion he adds to the original description the important characters of the form of the proboscis and of the bristles of the third longitudinal vein of the wings. The second paper is by Awati, who, in describing a new species of *Philaematomyia* from India, made a critical review of the genus,

dealing with the microscopical genital armature of *gurnei* in relation to that of the three other species of the genus.

Finally, in 1919, Stein (*b*, p. 40, and *c*, p. 47) repeated the characters and definitely placed his *Musca inferior* with his *Musca crassirostris* in the same group *Philaematomyia*, which, however, is not adopted as a distinct genus in the general catalogue of the exotic Anthomyidae (*a*, pp. 103-105).

I have, in my private collection, much very fine material of *Musca*, s.l., and of *Philaematomyia*, s.l., from Africa, Asia and Australia; and, moreover, I have at present in my hands the fine collection of these flies from the Indian Museum, Calcutta. I am thus now in a position to complete my attempt of 1911 (*b*, pp. 82-98) to distinguish the species of this important and difficult group on macroscopical characters only.

I am aware of the microscopical characters employed by Awati (1916, *a*) for the distinction of the Indian species, and I realise their importance in the exact specific determination in such a uniform group of insects as that of *Musca* and related forms. But I am always of the opinion that external macroscopical characters are, for practical purposes, more useful for quick determination. A number of these characters have already been used by Awati himself, who has also found some new ones (1916, *b*), such as tympanic bristles or hairs, hypopleural hairs, position of antennal grooves, etc., and others can always be discovered.

Thus, in examining my specimens of *inferior* (*gurnei*) I have found that they possess an important and easily visible character hitherto overlooked by all the writers, although well shown in the figures given by Patton and Cragg (1913, *a*, Pl. VII, and 1913, *c*, Pl. XLVII). I ascribe to this character such an importance that I think that it is sufficient for the erection of a new genus for the above-named species. In the higher and middle Myiadaria this is a matter of opinion; but it is true that all the main workers in these groups, beginning with Robineau-Desvoidy in 1830, following with Rondani and Brauer to Villeneuve and Tyler-Townsend to-day, have always mutiplied the genera.

Thus, while Stein, even in his most recent works on the Anthomyidae (1916 and 1919, *a*), has recognised only one great genus *Musca*, other writers have divided these forms into two sub-

families (*Philaematomyinae* and *Muscinae*), with no less than seven genera; *Philaematomyia*, *Pristirrhynchomyia*, *Viviparomusca*, *Musca* (*Promusca*), *Eumusca*, *Placosayia*, *Plexemya* and *Biomyia* (*Biomya*), and what, by Professor Stein, is considered to be only one species, under the name of *Musca corvina* (now better known as *autumnalis*), is referred to by others as two distinct species belonging even to two different genera, *Viviparomusca larvipara*, Portsch. (*Corvinoides*, Sehn. and Dziedz.) and *Eumusca autumnalis*, Deg. (*corvina*, Fabr., *ovipara*, Portsch.).

The character on which I erect the new genus is to be found on the calypters, the lower or thoracic squama of which bears, in *Ph. inferior* (*gurnei*), a number of dark hairs, easily visible with the aid of an ordinary lens; the hairs are placed on the inner part of the upper surface of the organ. This character is of great value in the classification of other flies, chiefly of the *Calliphorinae*; and, moreover, it is unique among the forms at present known in the groups *Philaematomyia* and *Musca*, s.l.

Ptilolepis, nov. gen.

Geno-type: *Musca inferior*, Stein, 1909.

Differing from all known genera, or sub-genera, of its group, in having the lower squama of the calypters hairy on its upper surface. The following additional characters of the genus must be recorded: Eyes bare, rather distant in the male. Parafrontal hairs of the female arranged in more than one row. Outer vertical bristles not developed in the male. Ocellar plate with many hairs and bristles. Facial ridges ciliated inferiorly. Proboscis thickened basally, with chitinous terminal teeth. Thorax with only one pair of strong post-sutural dorso-central bristles, before them another pair of much smaller ones; praesutural dorsocentral bristles entirely wanting; tympanic bristles present; no hypopleural hairs. One pair only of discal scutellar bristles, the anterior ones being much the smaller. Wings with the basal portion of the radius setose (with one bristle only), and with the third longitudinal vein setose on its whole length below (that is, on the under surface of the wing). Fourth longitudinal vein with a rounded, but deep, terminal bend, after which the apical cross-vein is concave outwardly.

To show the position of the new genus in relation to the other

known forms of Philaematomyine flies, the following table may be given :—

1 (2). Lower squama of calypters hairy above; tympanic bristles present, ocellar triangle bristly; facial bristles ascending; palpi of a yellowish colour; no distinct praesutural dorsocentral bristles; third longitudinal vein setose on the whole length below; abdomen with three longitudinal black stripes.. *Ptilolepis inferior*, Stein.

2 (1). Lower squama of calypters quite bare; no tympanic bristles or hairs; ocellar triangle not or less bristly; facial bristles not ascending; praesutural dorsocentral bristles short but distinct; third longitudinal vein quite bare, or exceptionally with one to two bristles only near its extreme base; abdomen with not more than one black longitudinal stripe.

3 (4). Basal bulb of the proboscis very much thickened; palpi yellowish; para-frontal hairs of the female in more than one row, acrostichal hairs near the suture disposed in eight or more irregular rows; abdomen of the male grey, destitute of shimmering areas, with a black discontinuous longitudinal stripe. *Philaematomyia crassirostris*, Stein.

4 (3). Proboscis not so thickened at base; palpi black; parafrontal hairs of the female in one row; acrostichal hairs in no more than four to six rows; abdomen of the male yellowish, with shimmering areas sometimes not very well developed.

5 (6). First abdominal segment of the male (Awati's second segment) entirely black; black longitudinal median stripe of abdomen continuous; smaller species 4 to 5 mm. in length, with oviparous female as in the preceding species. *Pristirrhynchomyia lineata*, Brunetti.

6 (5). First (Awati's second) abdominal segment of the male yellowish with black base and median stripes; black longitudinal stripe discontinuous; species of greater size, 5 to 6 mm. long, with larviparous female. *Pristirrhynchomyia indica*, Awati.

Catalogue of the Species.

I. *Ptilolepis inferior*, Stein.

Musca inferior, Stein (1909), p. 213; (1918) p. 149, (1919, *a*) p. 104; (1919, *b*) p. 40; (1919, *c*) p. 47; De Meijere (1918), p. 321.

Philaematomyia gurnei, Patton and Cragg (1912, *a*), p. 513; (1913, *a*) p. 28, Pl. VII, (1913, *c*) p. 356, Pl. XLVII, fig. 2; Cragg (1913), p. 23, Pl. V; Castellani and Chalmers (1913), p. 709; Awati (1918), p. 538, Pl. L, LI and LIV.

Philaematomyia inferior, Bezzi (1916), p. 29; (1917) p. 130; Banks (1919), p. 187.

In addition to the known localities of Java, Sumatra, India, Formosa and Philippines, I have the species from Annam, and, moreover, I have in my collection types which enable me to confirm the above synonomy. The present species, like the others, is found only on cattle; it was recorded without a name by Mitzmain (1912), p. 498 and (1913) p. 41, together with *crassirostris* and other flies, in his work on *Stomoxys calcitrans* and its bionomics in the Philippines.

II. *Philaematomyia crassirostris*, Stein.

Musca crassirostris, Stein (1903), p. 646; (1918) p. 148; (1919, *a*) p. 103; (1919, *c*) p. 47, Bezzi (1911, *a*), p. 117; De Meijere (1918), p. 321.

Philaematomyia insignis, Austen (1909, *a*), p. 298, figs. 1-3; (1909, *b*) p. 137, figs 1-3; Howlett (1909), p. 646, Pl. LXX; Brunetti (1910), p. 90, Pl. VIII; Alcock (1911), p. 162, fig. 62; Bezzi (1911, *a*), p. 117; Gedoelst (1911), p. 228; Cragg (1912), pp. 1-17, Pl. I-V; Patton and Cragg (1912), pp. 515-520, figs. 1-4; Surcouf and Gonzalez-Rincones (1912), p. 160, fig. 91; Brunetti (1913), p. 43; Castellani and Chalmers (1913), p. 709, Cragg (1913), p. 26, Pl. I; Patton and Cragg (1913, *a*), p. 26, Pl. VIII; (1913, *b*) p. 13; (1913, *c*) p. 357, Pl. XLVII; Cornwall and Patton (1914), p. 569; Fletcher (1916), p. 78; (1917) p. 91; Awati (1918), p. 539, Pl. L, LII and LIV.

Philaematomyia crassirostris, Bezzi (1911, *b*), pp. 88 and 98; (1916) p. 29; (1917) p. 130; Banks (1919), p. 187.

This species is common on cattle in tropical or sub-tropical

countries of Africa and Asia. It is recorded from Senegal, Congo Free State, Sokotra, India, Ceylon, Sumatra, Java, Borneo, Formosa and Philippines. I have also received specimens from Canton, South China, collected by Professor C. W. Howard.

In the Mediterranean sub-region, the species is known from Cyprus (Austen) and from Galilee (Brunetti), Becker has found it in Egypt at Cairo, Luxor and Assuan; but I have at present no records from North Africa or from South Europe.

The synonym was first proposed by me in 1911 and recorded by Patton and Cragg in 1913; I have since sent typical Indian specimens of *insignis* to Professor Stein, who has compared them with the types of *crassirostris* and has found them identical.

III. *Pristirrhynchomyia lineata*, Brunetti.

Pristirrhynchomyia lineata, Brunetti (1910), p. 91, figs. 1-2 and Pl. VIII; Gedoelst (1911), p. 229; Surcouf and Gonzalez-Rincones (1912), p. 161, fig. 92.

Philaematomyia lineata, Patton and Cragg (1912, *a*), p. 509, Pl. XXV; (1913, *a*) p. 27, Pl. VI; (1913, *c*) p. 356; Castellani and Chalmers (1913), p. 709; Cragg (1913), p. 20, Pl. IV; Awati (1918), p. 539, Pl. L. and LIV.

Known only from India at present; but Professor Stein (1909, p. 212) has already described it from Java without a name as a variety of *Musca pollinosa*, Stein. This last species, of course, is a true *Eumusca*, which I have seen from Annam.

The species, of which I have seen a co-type in the Indian Museum collection, does not seem to be rare; I have before me numerous specimens from S. India, Trichinopoly (*Cajus*), and some others from S. China, Canton (Professor C. W. Howard).

IV. *Pristirrhynchomyia indica*, Awati.

Musca indica, Awati (1916), p. 138.

Philaematomyia indica, Awati (1918), p. 529, Pl. L-LV.

I have before me a male specimen of what I believe to be the present species; it was caught in Southern India, Trichinopoly (*Cajus*).

I have here placed the species in *Pristirrhynchomyia*; but the larviparous habit of the female, unique in the tribe, shows that the

present species is not congeneric with the others, as indicated also by the reproductive characters and by the more developed praesutural dorsocentral bristles. In this case a new genus must be erected for it, and all the four known genera of Philaematomyine flies will become monotypic.

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NOTE

From the above Bibliography it is interesting to remark how recent our knowledge of the *Philaematomyine* flies is, being all subsequent to 1900. The dates of description of the four known species are 1903, 1909, 1910 and 1916; no doubt additional forms still remain to be discovered, but it seems that they must, in all probability, be only a few in number.

SOME STATISTICS OF FILARIASIS

BY

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Manson-Bahr's valuable monograph on Filariasis (1912) contains data which enable us to ascertain the microfilaria rate among persons with signs of 'filarial' disease, and, conversely, the disease rate among those infected with microfilaria. The value of these data lies in the fact that the author also gives control data, which similarly enable us to ascertain the respective rates among those without signs of disease and among those without microfilaria. It is exceptional to find such data in the literature, and almost always there is an absence of control observations. We may find recorded, for example, the microfilaria rate of a number of elephantiasis cases without any other information; this record by itself has little or no value, for if elephantiasis had no connection with filaria we should still expect such cases to show microfilaria if they formed part of a population infected with microfilaria.

Manson-Bahr presents his data in a summarised form in several tables. On studying these, several questions arose on which it seemed important to get further information, but it was not possible to do so from the summaries. Having written to Dr. Manson-Bahr on the matter, he very kindly placed at my disposal his note-books containing the protocols which his tables summarise, and I must express here my gratitude for his generosity in so doing. From the protocols I have compiled the tables given in this paper. Manson-Bahr's tables summarise observations made on 949 people; and in the protocols I have been able to trace 944 of these. For the form in which I have analysed these data I am alone responsible, and no blame attaches to Dr. Manson-Bahr for any errors on my part.

Our knowledge of the number and distribution of adult worms (*Filaria bancrofti*) in the body, and of the way in which they cause (*ex hypothesi*) the various lesions of the lymphatic system embraced in the term 'filarial disease,' is incomplete. Consequently authors have sought to strengthen the evidence for the association of adult worms with filarial disease by the use of evidence based on the association of embryos in the blood with various signs of the disease.

That it is not an easy matter to interpret such evidence the following considerations may shew :—

(1) The *presence* of microfilaria in the blood may indicate (*a*) the presence of a mature living female worm or worms in the body or (*b*) the previous existence of such worms (now dead), because microfilaria, for all we know to the contrary, may live in the blood for an indefinite period.

(2) The *absence* of microfilaria in the blood may indicate the absence of adult worms in the body, but not necessarily so, as living females have been found post-mortem, the presence of which was not revealed by microfilaria in the blood during life.

(3) The *presence* of signs of filarial disease may indicate (*a*) the presence of a living worm or worms in the body in association with the lesion, or (*b*) the presence of a dead or disintegrated worm, or (*c*) a lesion persisting after the complete absorption of a worm.

(4) The *presence* of signs of filarial disease with microfilaria in the blood does not necessarily imply that the parent of the embryos is the cause of the lesion. The worm that caused the lesion may be dead or alive; if the latter, it may not have embryos in the blood.

(5) The *absence* of signs of filarial disease without microfilaria in the blood does not necessarily imply an absence of adult worms, as the worms may not have been present in the body sufficiently long to produce (*ex hypothesi*) a lesion.

TABLE I. See foot note.

Shewing percentage infected with microfilaria among those with and without signs of filarial disease* in Fij.

	Number examined	Number infected with microfilaria	Percentage
With signs of filarial disease	417	152	36·4
Without signs of filarial disease	527	103	19.5

* The only 'signs of disease' considered throughout this paper are enlarged lymphatic glands, hydrocele, enlarged testis, abscess, and elephantiasis.

Conclusion: Microfilaria is commoner among those with signs of filarial disease than among those without signs of filarial disease.

For a further analysis of this table, *vide* Appendix, Table XII.

ERRATA

Vol. XIV, No. 3, p. 342, Table I: for 103 : 19·5 read 108 : 20·5; and p. 343, Table III: for 269 : 39·3 read 265 : 38·7.

TABLE II.

Shewing percentage infected with microfilaria among those with and without particular signs of filarial disease in Fiji.

	Number examined	Number infected with microfilaria	Percentage
With elephantiasis	33	13	39·4
Without elephantiasis	911	247	27·1
With enlarged glands	325	118	36·3
Without enlarged glands	619	142	22·9
With hydrocele	50*	20	40·0
Without hydrocele	462*	142	30·7
With enlarged testis	34*	11	32·3
Without enlarged testis	478*	151	31·6
With abscess†	209	97	46·4
Without abscess	735	163	22·2

* Males.

† We understand from Dr. Manson-Bahr that in many cases cicatrices were taken as evidence of a pre-existing abscess.

Conclusion: Microfilaria is commoner among those with elephantiasis, enlarged glands, hydrocele, enlarged testis, or abscess than among those without these signs of filarial disease.

For a further analysis of the table, *vide* Appendix, Table XIII.

TABLE III. See foot note

Shewing percentage exhibiting signs of filarial disease among those with and without microfilaria, in Fiji.

	Number examined	Number with signs of filarial disease	Percentage
With microfilaria	260	152	58·4
Without microfilaria	684	269	39·3

Conclusion: Signs of filarial disease are commoner among those infected with microfilaria than among those not infected with microfilaria.

For a further analysis of this table, *vide* Appendix, Table XIV.

TABLE IV.

Shewing percentage exhibiting particular signs of filarial disease among those with and without microfilaria, in Fiji.

	Number examined	Number with particular signs of filarial disease	Percentage
		ELEPHANTIASIS	
With microfilaria	260	13	5·0
Without microfilaria	684	20	2·9
		GLANDS	
With microfilaria	260	118	45·3
Without microfilaria	684	207	30·2
		HYDROCELE	
With microfilaria	162*	20	12·3
Without microfilaria	350*	30	8·5
		ENLARGED TESTIS	
With microfilaria	162*	11	6·7
Without microfilaria	350*	21	6·0
		ABSCESS	
With microfilaria	260	97	37·3
Without microfilaria	684	112	16·3

* Males.

Conclusion: Cases of elephantiasis, enlarged glands, hydrocele, abscess, and enlarged testis, respectively, are commoner among those infected with microfilaria than among those not infected with microfilaria.

For a further analysis of this table, *vide* Appendix, Table XV.

TABLE V.

Shewing percentage infected with microfilaria and percentage shewing signs of disease at various age periods in the population examined, in Fiji.

Age period	Number examined	Percentage infected with microfilaria	Percentage shewing signs of filarial disease	
		MALE		
1–10	85	1·2	18·8	18·8*
11–20	117	21·4	59·0	59·0*
21–30	108	39·8	64·8	64·8*
31–40	83	47·0	78·3	78·3*
41–50	63	52·4	69·8	66·6*
51–60	35	37·1	71·4	62·8*
61–	21	38·1	76·2	61·9*
		FEMALE		
1–10	66	10·6	9·1	
11–20	108	24·0	20·3	
21–30	124	22·6	31·4	
31–40	61	22·9	34·4	
41–50	41	34·1	26·8	
51–60	19	26·3	52·6	
61–	13	30·7	23·0	

*** Hydrocele and enlarged testis excluded.**

Conclusion: No close relationship between the two sets of percentages is evident.

Manson-Bahr investigated five areas in Fiji. It is interesting to compare the microfilaria rate with the filarial disease rate in the areas.

TABLE VI.

Shewing percentage infected with microfilaria and percentage shewing signs of disease in various Fijian localities.

Locality	Number examined	Percentage infected with microfilaria	Percentage with signs of filarial disease (including elephantiasis)	Percentage with elephantiasis
Bau	169	13·0	28·9	0·0
Oneata	114	24·6	38·6	1·8
Lakemba Villages	178	24·7	48·8	5·0
Lakemba Town	264	33·7	60·0	7·5
Loma Loma	219	35·6	35·1	1·8

Conclusion: No close relationship between the two sets of percentages is evident.

Dr. Manson-Bahr has also kindly furnished me with unpublished observations made by him in Ceylon. From these I have compiled the following tables.

TABLE VII.

Shewing percentage infected with microfilaria among those with and without signs of filarial disease, in Ceylon.

	Number examined	Number infected with microfilaria	Percentage
With signs of filarial disease	52	4	7·7
Without signs of filarial disease	1256	39	3·1

TABLE VIII.

Shewing percentage infected with microfilaria among those with and without particular signs of filarial disease, in Ceylon.

	Number examined	Number infected with microfilaria	Percentage
With elephantiasis	46	2	4·3
Without elephantiasis	1262	41	3·2
With enlarged glands	35	2	5·7
Without enlarged glands	1273	41	3·2
With hydrocele	7*	0	0
Without hydrocele	957*	40	4·2
With abscess	1	0	0
Without abscess	1307	43	3·3

* Males. NOTE :—No record is made of enlarged testis.

Conclusion: Microfilaria is commoner among those with elephantiasis, enlarged glands, or hydrocele than among those without these signs of filarial disease.

TABLE IX.

Shewing percentage exhibiting signs of filarial disease among those with and without microfilaria, in Ceylon.

	Number examined	Number with signs of filarial disease	Percentage
With microfilaria	43	4	9·3
Without microfilaria	1265	48	3·8

Conclusion: Signs of filarial disease are commoner among those infected with microfilaria than among those not infected with microfilaria.

TABLE X.

Shewing percentage exhibiting particular signs of filarial disease among those with and without microfilaria, in Ceylon.

	Number examined	Number with particular signs of filarial disease	Percentage
		ELEPHANTIASIS	
With microfilaria	43	2	4·6
Without microfilaria	1265	44	3·5
		ENLARGED GLANDS	
With microfilaria	43	2	4·6
Without microfilaria	1265	33	2·6
		HYDROCELE	
With microfilaria	40*	0	0
Without microfilaria	924*	7	0·7
		ABSCESS	
With microfilaria	43	0	0
Without microfilaria	1265	1	0·08

* Males. NOTE.—No record is made of enlarged testis.

Conclusion: Elephantiasis and enlarged glands are commoner among those infected with microfilaria than among those not infected with microfilaria; the reverse holds true for hydrocele.

Finally a comparison may be made between the various rates obtained for Fiji and Ceylon.

TABLE XI.

Shewing various rates in Fiji and Ceylon.

	FIJI	CEYLON
Number examined	944	1308
	Percentage	Percentage
Microfilaria rate	27·0	3·3
Enlarged glands rate	34·4	2·6
Hydrocele rate	9·7*	0·7*
Abscess rate	22·1	0·08
Enlarged testis rate	6·2*	0·0*
Elephantiasis rate	3·4	3·5

* Male rate

Conclusion: The microfilaria rate of those examined in Fiji is higher than that of those examined in Ceylon, and the rates for enlarged glands, hydrocele and abscess are also higher, but there is no evident correlation between the two sets of figures. Although the microfilaria rate of those examined in Fiji is more than eight times as great as that of those examined in Ceylon, yet the elephantiasis rates are the same.

While it is permissible—given the microfilaria rate of those examined in each of two countries—to compare other rates solely in relation to the respective microfilaria rates, it is not permissible to compare independently any two corresponding rates, *e.g.*, the microfilaria rates, unless we know that they are derived from homogeneous populations. Thus, there appears to be evidence that the microfilaria rates, in some countries at least, vary with the age periods, so that in such cases the rates could not be compared unless we knew that each population examined contained, *e.g.*, the same proportion of children under ten; but if we restrict our comparison to people of a particular age period (and sex), then the comparison is, within limits, valid. Further, it is not permissible, in strictness, to speak of the microfilaria rate of a country, unless we examine the whole population, as was virtually done by Manson-Bahr in certain of the Fijian islands. Where this is impossible, if we wish to get a figure representing the microfilara rate of a country, we must select our population in proportion to the *number of people alive at each age period*. This latter information can only be obtained from the census figures which, even where they exist in the tropics, are of doubtful accuracy.

SUMMARY

1. Microfilaria is commoner among those with signs of filarial disease than among those without signs of filarial disease.

2. Signs of filarial disease are commoner among those infected with microfilaria than among those not infected with microfilaria.

3. There is no evident correlation between various microfilaria rates and the corresponding filarial disease rates.

REFERENCE

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Table XII.

(Analysis of Table I).

Shewing percentage infected with microfilaria among those with and without signs of filarial disease, at different age periods, in Fiji.

Age period		Male: Number examined	Male: Number infected with microfilaria	Male: Percentage infected with microfilaria	Female: Number examined	Female: Number infected with microfilaria	Female: Percentage infected with microfilaria
1–10	With signs	16	0	0·0	6	2	33·3
	Without signs ...	69	1	1·4	60	5	8·3
11–20	With signs	69	17	24·6	22	7	31·8
	Without signs ...	48	8	16·6	86	19	22·1
21–30	With signs	70	30	42·8	39	9	23·0
	Without signs ...	38	13	34·2	85	19	22·3
31–40	With signs	65	34	52·3	21	5	23·8
	Without signs ...	18	5	28·0	40	9	22·5
41–50	With signs	44	24	54·5	11	5	45·4
	Without signs ...	19	9	47·4	30	9	30·0
51–60	With signs	25	10	40·0	10	2	20·0
	Without signs ...	10	3	30·0	9	3	33·3
61–	With signs	16	6	37·5	3	1	33·3
	Without signs ...	5	2	40·0	10	3	30·0

TABLE XIII.

(Analysis of Table II).

Shewing the percentage infected with microfilaria among those with and without particular signs of filarial disease at different age periods, in Fiji.

Age period		Male			Female		
		Number examined	Number infected with microfilaria	Percentage infected with microfilaria	Number examined	Number infected with microfilaria	Percentage infected with microfilaria
1–10	With abscess ...	2	0	0·0	0	0	0·0
	Without abscess ...	83	1	1·2	66	7	1·1
	With glands ...	15	0	0·0	6	2	33·3
	Without glands ...	70	1	1·4	60	5	8·3
	With hydrocele ...	0	0	0·0	...	...	...
	Without hydrocele ...	85	1	1·2	...	...	...
	With testis ...	0	0	0·0	...	...	...
	Without testis ...	85	1	1·2	...	...	...
	With elephantiasis ...	0	0	0·0	0	0	0·0
	Without elephantiasis	85	1	1·2	66	7	1·1
11–20	With abscess ...	21	7	33·3	10	3	30·0
	Without abscess ...	96	18	18·7	98	23	23·5
	With glands ...	61	14	22·9	14	4	28·6
	Without glands ...	56	11	19·6	94	22	23·4
	With hydrocele ...	0	0	0·0	...	...	...
	Without hydrocele ...	117	25	21·3	...	...	...
	With testis	1	0	0·0	...	...	...
	Without testis ...	116	25	21·5	...	...	...
	With elephantiasis ...	0	0	0·0	0	0	0·0
	Without elephantiasis	117	25	21·3	108	26	24·0
21–30	With abscess ...	39	18	46·1	16	4	25·0
	Without abscess ...	69	25	36·2	108	24	22·2
	With glands	57	25	43·8	26	6	23·0
	Without glands ...	51	18	35·3	98	22	22·4
	With hydrocele ...	6	0	0·0	...	...	...
	Without hydrocele ...	102	43	42·1	...	...	...
	With testis	4	1	25·0	...	...	...
	Without testis ...	104	42	40·4	...	...	...
	With elephantiasis ...	3	1	33·3	0	0	0·0
	Without elephantiasis	105	42	40·0	124	28	22·6

TABLE XIII—*continued*

Age period		Male: Number examined	Male: Number infected with microfilaria	Male: Percentage infected with microfilaria	Female: Number examined	Female: Number infected with microfilaria	Female: Percentage infected with microfilaria
31–40	With abscess ...	43	28	65·1	11	3	27·2
	Without abscess ...	40	11	27·5	50	11	22·0
	With glands ...	54	27	50·0	12	3	25·0
	Without glands ...	29	12	41·4	49	11	22·4
	With hydrocele ...	18	7	38·9	...	...	...
	Without hydrocele ...	65	32	49·2	...	...	...
	With testis	4	3	75·0	...	...	...
	Without testis ...	79	36	45·5	...	...	...
	With elephantiasis ...	7	4	57·1	3	0	0·0
	Without elephantiasis	76	35	46·0	58	14	24·1
41–50	With abscess ...	31	17	54·8	8	5	62·5
	Without abscess ...	32	16	50·0	33	9	27·3
	With glands ...	37	20	54·0	7	3	42·8
	Without glands ...	26	13	50·0	34	11	32·3
	With hydrocele ...	15	10	66·6	...	...	...
	Without hydrocele ...	48	23	47·9	...	...	...
	With testis	10	2	20·0	...	...	...
	Without testis ...	53	31	58·5	...	...	...
	With elephantiasis ...	6	2	33·3	1	1	100·0
	Without elephantiasis	57	31	54·4	40	13	32·5
51–60	With abscess ...	14	9	64·3	5	0	0·0
	Without abscess ...	21	4	19·0	14	5	35·7
	With glands ...	19	9	47·4	6	1	16·6
	Without glands ...	16	4	25·0	13	4	30·7
	With hydrocele ...	10	4	40·0	...	...	...
	Without hydrocele ...	25	9	36·0	...	...	...
	With testis	7	2	28·5	...	...	...
	Without testis ...	28	11	39·3	...	...	...
	With elephantiasis ...	7	3	42·8	2	1	50·0
	Without elephantiasis	28	10	35·7	17	4	23·5
61–	With abscess ...	7	2	28·5	3	1	33·3
	Without abscess ...	14	6	42·8	10	3	30·0
	With glands ...	11	4	36·3	0	0	0·0
	Without glands ...	10	4	40·0	13	4	30·7
	With hydrocele ...	2	0	0·0	...	...	...
	Without hydrocele ...	19	8	42·1	...	...	...
	With testis	8	3	37·5	...	...	...
	Without testis ...	13	5	38·4	...	...	...
	With elephantiasis ...	4	1	25·0	1	0	0·0
	Without elephantiasis	17	7	41·2	12	4	33·3

TABLE XIV.

(Analysis of Table III).

Shewing percentage exhibiting signs among those with and without microfilaria, at different age periods, in Fiji.

Age period		Male			Female		
		Number examined	With signs	Percentage	Number examined	With signs	Percentage
1–10	With microfilaria ...	1	0	0·0	7	2	28·6
	Without microfilaria	84	16	19·0	59	4	6·8
11–20	With microfilaria ...	25	17	68·0	26	7	27·0
	Without microfilaria	92	52	56·5	82	15	18·3
21–30	With microfilaria ...	43	30	69·7	28	9	32·1
	Without microfilaria	65	40	61·5	96	30	31·2
31–40	With microfilaria ...	39	34	87·2	14	5	35·7
	Without microfilaria	44	31	70·5	47	16	34·0
41–50	With microfilaria ...	33	24	72·1	14	5	35·7
	Without microfilaria	30	20	66·6	27	6	22·2
51–60	With microfilaria ...	13	10	76·9	5	2	40·0
	Without microfilaria	22	15	68·1	14	8	57·1
61–	With microfilaria ...	8	6	75·0	4	1	25·0
	Without microfilaria	13	10	76·9	9	2	22·2

TABLE XV.

(Analysis of Table IV).

Shewing percentage exhibiting particular signs of filarial disease among those with and without filarial disease, at different age periods in Fiji.

Age period		Male						Female			
		Number examined	Abscess	Glands	Hydrocele	Testis	Elephantiasis	Number examined	Abscess	Glands	Elephantiasis
1–10	With microfilaria ...	1	0	0	0	0	0	7	0	28·6	0
	Without microfilaria	84	2·4	17·8	0	0	0	59	0	6·8	0
11–20	With microfilaria ...	25	28·0	56·0	0	0	0	26	11·5	15·4	0
	Without microfilaria	92	15·2	51·1	0	1·1	0	82	8·5	12·2	0
21–30	With microfilaria ...	43	41·8	58·1	0	2·3	2·3	28	14·3	21·4	0
	Without microfilaria	65	32·3	49·2	9·2	1·5	1·5	96	11·4	20·8	0
31–40	With microfilaria ...	39	71·8	69·2	15·4	7·7	10·2	14	21·4	21·4	0
	Without microfilaria	44	34·1	61·4	25·0	2·3	6·8	47	17·0	19·1	6·4
41–50	With microfilaria ...	33	51·5	60·6	30·3	6·1	6·1	14	35·7	21·4	7·1
	Without microfilaria	30	46·6	56·6	16·6	26·6	13·3	27	11·1	14·8	0
51–60	With microfilaria ...	13	69·2	69·2	30·7	15·4	23·1	5	0	20·0	20·0
	Without microfilaria	22	22·7	45·4	27·3	22·7	18·2	14	35·7	35·7	7·1
61–	With microfilaria ...	8	25·0	50·0	0	37·5	12·5	4	25·0	0	0
	Without microfilaria	13	38·4	53·8	15·4	38·5	23·1	9	22·2	0	11·1

A NEW SPECIES OF CESTODE (*ANOPLOCEPHALA VULGARIS*) FROM AN AFRICAN RHINOCEROS

BY

T. SOUTHWELL

(*Received for publication* 8 *December*, 1920)

Twelve specimens, a large number of fragments, and several single segments, were obtained by Professor Yorke on 23rd August, 1912, from a rhinoceros (*Rhinoceros bicornis*), at Ngoa, N.E. Rhodesia.

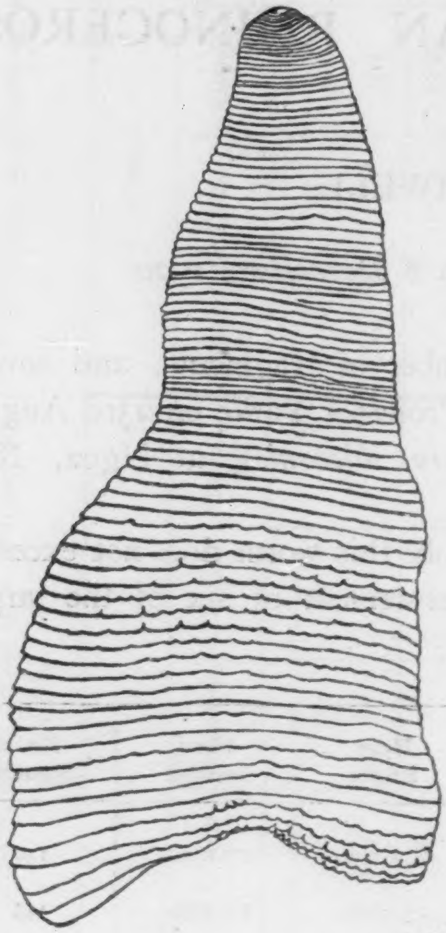
EXTERNAL CHARACTERS. Probably this worm does not exceed a length of about 12 cm. The measurement of six of the largest specimens were as follows:—

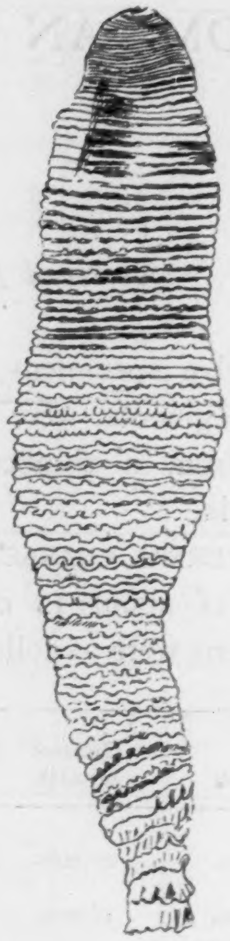
Length	Greatest breadth	Greatest thickness	Head length	Head breadth	No. of Segments
75 mm.	27 mm.	1·0 mm.	0·75 mm.	1·0 mm.	150
67 mm.	16 mm.	1·25 mm.	0·5 mm.	1·0 mm.	143
60 mm.	15 mm.	0·75 mm.	1·1 mm.	1·25 mm.	117
48 mm.	11 mm.	1·5 mm.	0·5 mm.	1·1 mm.	114
47 mm.	16 mm.	0·75 mm.	no	head	125
44 mm.	17 mm.	0·75 mm.	0·5 mm.	1·0 mm.	121

The worms vary in shape, as will be seen from figs. 1 and 2. In some, the posterior segments are very broad (27 mm.), and short (1 mm.), whilst in others they are narrow (4 mm.) and long (1·25 mm). The segments overlap each other, and the free edges are frilled, the frilling becoming much more pronounced posteriorly. The genital pores are all dextral.

HEAD. The head is very small (figs. 1, 2 and 3). The four suckers are directed forward and slightly outward. Their diameter is about 390μ, and the muscular rim has a thickness of about 80μ. There are no lappets, and there is no neck. The lateral margins of

the anterior segments curve forward so that the head rests in a deep depression between two shoulders, and can be seen only with difficulty with the naked eye (figs. 1 and 2).





FIGS. 1 and 2. Two specimens shewing variation in shape. (× 2.)

MUSCULAR SYSTEM. The muscular system is poorly developed; the longitudinal bundles have a thickness of about 50μ, and the annular bundles of 15μ; a single bundle of muscle fibres connects the

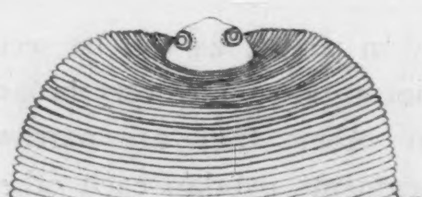


FIG. 3. Head and anterior segments. (× 10.)

internal extremity of the cirrus bulb to the ventral wall. The dorso-ventral muscle fibres are strongly developed, and extend, at irregular intervals, from the dorsal to the ventral surface (figs. 5 and 8).

NERVOUS SYSTEM. There are three longitudinal nerves on each side, the main nerve being median. The other two are small and are situated lateral to the main nerve, one dorsal and one ventral (figs. 4 and 5).

WATER VASCULAR SYSTEM. Only a single vessel could be made out with certainty on each side. It was well developed, and had a diameter of about 45μ. Numerous branches were to be seen, especially laterally (figs. 4 and 5).

MALE GENITALIA. *Testes* (figs. 4, 5 and 6). These first appear in segment 15, and they have disappeared in segment 62. At first they are small, each testis having a diameter of about 20μ only.

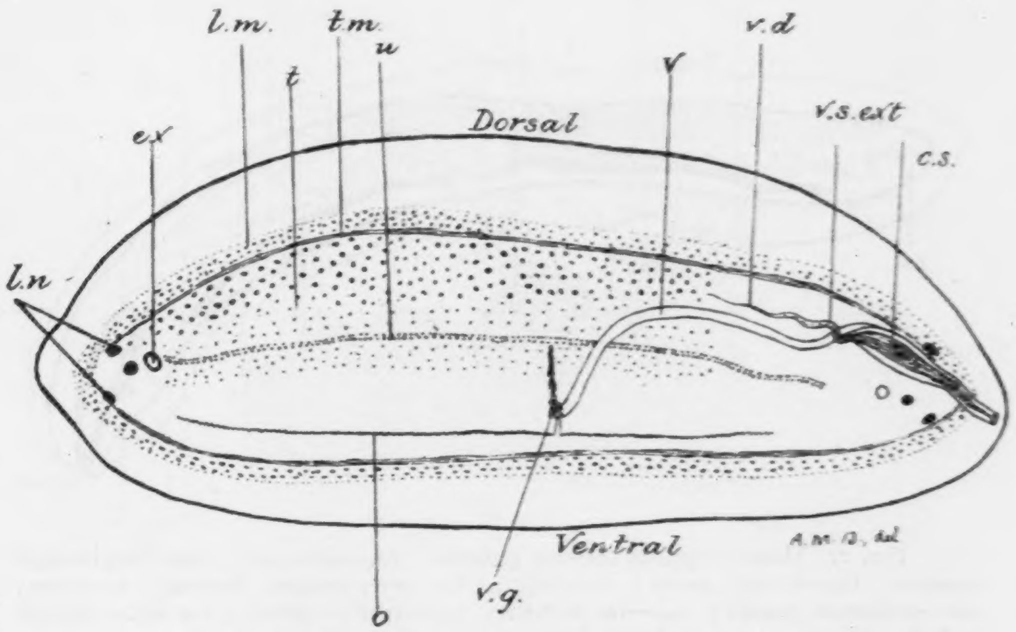


FIG. 4. Immature segment shewing developing of genitalia. *c.s.*—cirrus sac; *e.x.*—ventral excretory vessel; *l.m.*—longitudinal muscles; *l.n.*—lateral nerves; *o.*—ovary; *t.*—testes; *t.m.*—transverse muscles; *u.*—uterus; *v.*—vagina; *v.d.*—vas deferens; *v.g.*—vitelline glands; *v.s. ext.*—external vesicula seminalis. (× 28.)

They attain their maximum development between segments 18 and 24, where each testis measures about 62μ by 30μ. When fully developed, they extend the whole distance between the aporal water vessel and the inner extremity of the cirrus bulb. While the bulk of the testes lies dorsally, a number of acini extend quite ventrally and reach the rudiment of the ovaries.

Vas deferens. The cirrus bulb is first evident in segment 10, where it measures about 250μ by 150μ. The rudiment of the outer seminal vesicle is also to be seen in this segment, lying immediately

internal to the cirrus bulb (fig. 4). In segment 23, the cirrus bulb has enlarged to 900μ, and its breadth is 275μ; it lies dorsal to the water vessel and nerve and gradually curves ventrally, until its internal extremity lies almost on the ventral surface. The outer seminal vesicle lies internal and dorsal to the cirrus bulb; it is a U-shaped tube having a diameter of about 40μ, the limbs of which lie close together. The inner limb gradually merges into the vas deferens, which narrows and pursues a wavy course along the dorsal surface. The inner seminal vesicle is first visible in segment 26, as a small club-shaped cavity near the internal extremity of the cirrus bulb; it enlarges rapidly, like the cirrus bulb itself, and

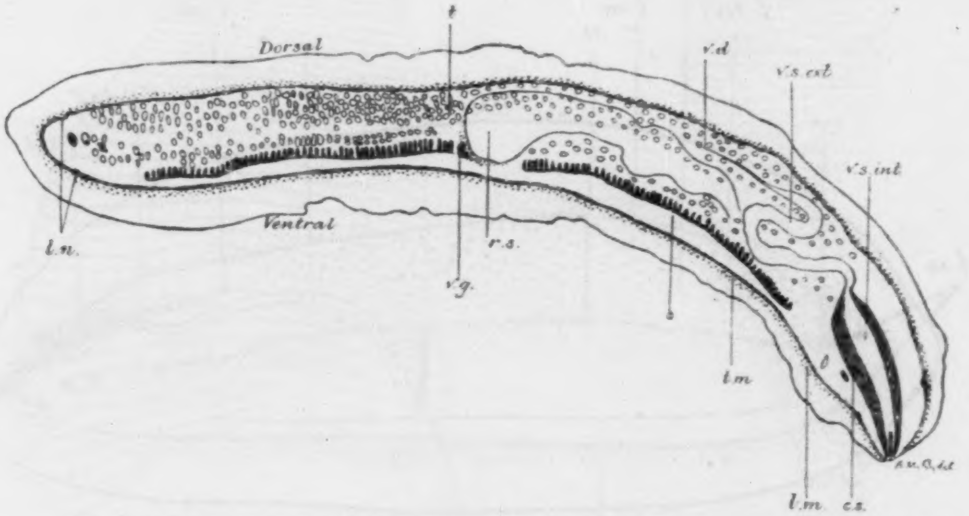


FIG. 5. Mature segment shewing genitalia. *c.s.*—cirrus sac; *l.m.*—longitudinal muscles; *l.n.*—lateral nerves; *o.*—ovary; *r.s.*—receptaculum seminis; *t.*—testes; *t.m.*—transverse muscles; *v.d.*—vas deferens; *v.g.*—vitelline glands; *v.s. ext.*—external vesicula seminalis; *v.s. int.*—internal vesicula seminalis. (× 14.)

in segment 37 practically fills the entire cirrus bulb. The cirrus shortens as the inner seminal vesicle enlarges, and eventually disappears altogether. No spines were seen on the cirrus.

In segment 50 the cirrus bulb is about 2 mm. long and has a diameter of 0·45 mm. It continues of this size up to about segment 80, when it gradually becomes straighter and narrower; it persists to the last segment. The outer seminal vesicle also enlarges enormously and alters its position accordingly up to segment 46, after which it gradually shrinks.

FEMALE GENITALIA. *Ovary* (figs. 4, 5 and 6). This first appears in segment 19; it is situated ventrally and measures 45μ

in the dorso-ventral diameter. It attains its highest development between segments 37 and 50, and disappears in segment 64. When fully developed, it extends laterally to within 650μ of the aporal water vessel, and to within 700μ of the poral water vessel. The ovary is divided into two wings by the vitelline glands; the poral wing has a lateral diameter of about 2·2 mm., and the aporal wing of 3·5 mm. (figs. 5 and 6). The median axis of the ovary is very slightly on the pore side of the segment.

The ovary consists of a series of club-shaped acini arising from a ventral horizontal base (fig. 6); the larger acini measure about

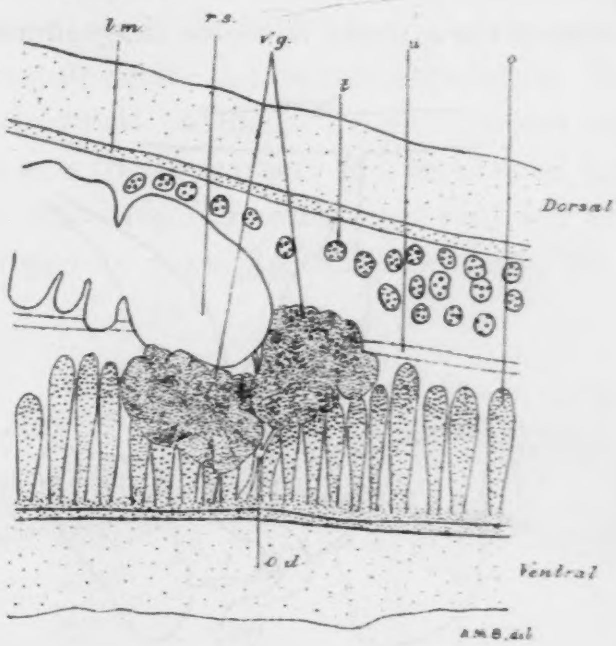


FIG. 6. Centre of a mature segment. *l.m.*—longitudinal muscles; *o.*—ovary; *o.d.*—oviduct; *r.s.*—receptaculum seminis; *t.*—testes; *u.*—uterus; *v.g.*—vitelline glands. (× 35.)

470μ dorso-ventrally, and 60μ laterally. They decrease in size towards the periphery of the ovary to a slight extent only.

Receptaculum and Vagina. In segment 12 the vagina is well defined as a clear irregular tube having a diameter of about 70μ, and in segment 14 the receptaculum is seen as a slight dilatation of the median extremity of the vagina. Both the vagina and the receptaculum increase in size rapidly, and become enormously distended; in segment 29 the vagina has a diameter of about 450μ, and the receptaculum fills the whole dorso-ventral area (fig. 5). After segment 51, both these structures atrophy quickly. The

vagina has the following relationship to the cirrus bulb; from the genital pore it runs inwards, ventral to the bulb, but dorsal to the excretory vessel and nerve: it then crosses posterior to the cirrus bulb and runs dorsal to it.

In the median direction the receptaculum is continued as a narrow tube, which is joined by the oviduct and continues in a dorsal direction as a long fertilisation canal to the uterus. After the vitelline glands and receptaculum seminis are well developed, they hide the other structures in the vicinity, but it was noted that the vitelline duct opens near the junction of the oviduct and fertilisation canal, posterior and ventral to the receptaculum seminis. The relative position of these ducts is shewn diagrammatically in fig. 7.

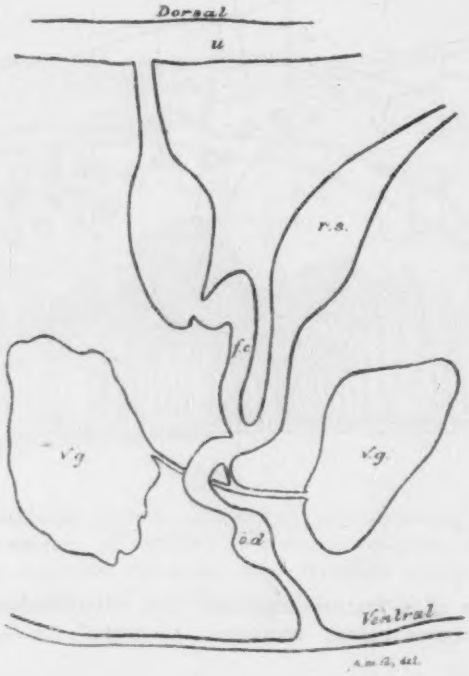


FIG. 7. Diagrammatic representation of the connections of the receptaculum seminis, ovary, oviduct, vitelline glands and uterus. *f.c.*—fertilisation canal; *o.d.*—oviduct; *r.s.*—receptaculum seminis; *u.*—uterus; *v.g.*—vitelline glands.

Vitelline glands. The rudiment of the vitelline glands appears with that of the receptaculum in segment 8, and in segment 14 a few small vitelline acini are present. The vitelline glands practically disappear in segment 94, but traces of them persist up to segment 99. They reach their maximum development between segments 44 and 50, and consist of two definite wings, separated from each other and presenting a V-shaped appearance. The poral wing is smaller than the aporal wing, the former measuring about 370μ by 200μ,

and the latter 390μ by 390μ; each is lobulated. Both wings lie on, but not touching, the ventral surface (figs. 6 and 7).

Shell glands. The shell gland consists in segments 24 to 27 of a thickening on the wall of the fertilisation canal, which measures about 75μ by 55μ. In posterior segments it could not be found.

Uterus. The rudiment of the uterus is to be seen in segment 7 or 8. In segment 17, it consists of a very faint cell-string running midway between the dorsal and ventral surfaces (fig. 4). Its future development was followed with some difficulty, owing to the fact that the testes, ovaries and receptaculum masked its presence. In segment 28, it runs between the ovaries and the testes as a straight tube from one water vessel to the other. In segment 48, it has enlarged a little and its course has become undulating. In succeeding segments, the undulations become more pronounced, and in about segment 70 it presents the appearance of a number of vertical tubes, not always clearly separated from each other ventrally and dorsally, and containing immature eggs (fig. 8). Laterally, the extremities

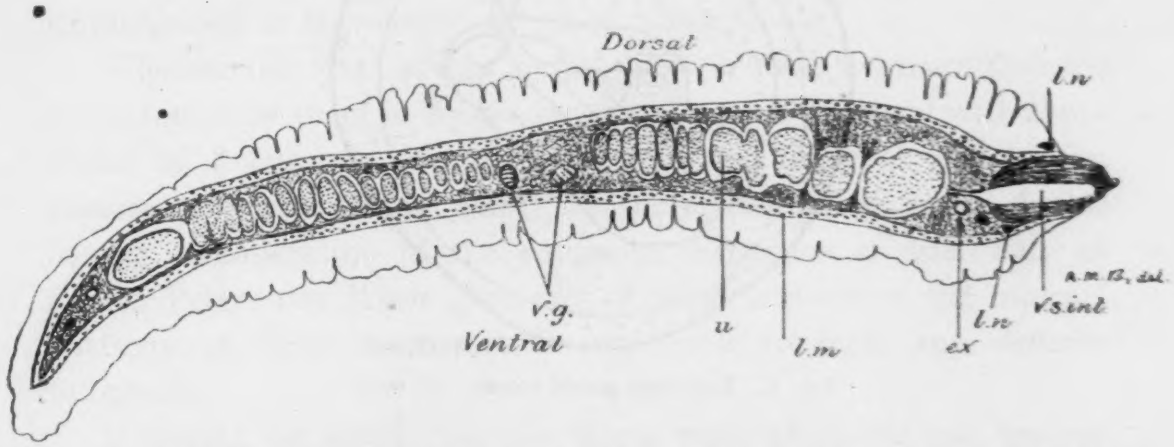


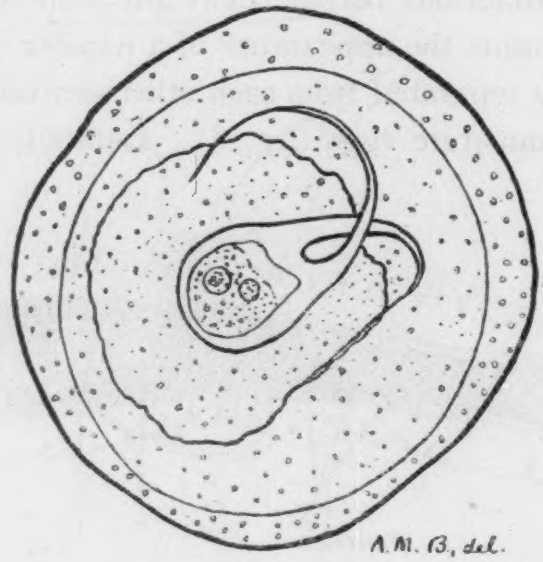
FIG. 8. Gravid uterus, posterior view, shewing isolated compartments into which the uterus is divided. *ex.*—ventral excretory vessel; *l.m.*—longitudinal muscles; *l.n.*—lateral nerves; *u.*—uterus; *v.g.*—vitelline glands; *v.s. int.*—internal vesicula seminalis. (× 14.)

of the uterus remain straight and dilated. In the posterior segments the uterus fills the proglottid entirely, and dorso-ventral and antero-posterior muscular partitions can be seen with great clearness in whole segments or in sections viewed either anteriorly, posteriorly, dorsally or ventrally. No sterile segments were observed.

Eggs. The eggs enlarge and mature gradually in the posterior segments, the pyriform apparatus appearing last. The mature eggs

in preserved specimens are of different shapes and sizes, a condition which appears to be dependent on reciprocal pressure in the uterus. Extreme types are either ovoid or cuboid, the latter predominating (fig. 9), but intermediate types occur in abundance. In preserved specimens the egg has the following dimensions:—Size of egg, 77μ to 95μ. Thickness of outer envelope, 16μ to 18μ. Diameter of embryo, 18μ to 19μ. Length of horns of pyriform apparatus, 18μ. The free egg in the fresh condition is undoubtedly spherical.

In immature eggs the middle envelope lies close to the outer envelope. As the egg matures the middle envelope gradually shrinks until it becomes a small mass, about 1μ to 2μ in diameter, attached to the filaments of the pyriform apparatus. Its size,



A.M.B., del.

FIG. 9. Eggs from gravid uterus. (× 600.)

therefore, cannot be given. The eggs contain numerous yolk particles and granular material. The horns cross each other in very mature eggs, and each horn grows out into a long filament which becomes applied to the outer face of the vitelline envelope. The segments drop off either singly or in clusters of two, three, or four. When single they assume peculiar shapes.

DIAGNOSIS. Peters, in 1856, published a description of the external characters of a tapeworm from an African rhinoceros from Mozambique, to which he gave the name *T. gigantea*. The length of the worm was stated to be 12 cms. and the maximum breadth

as 27 to 29 mm. Some years later, Murie (1870) wrote 'A couple of years ago some dozen joints of what I may safely term an enormous tapeworm were placed in my hands by Mr. Bartlett, they having been passed by the young male *Rhinoceros indicus* in the Gardens.' He gives a brief description of the external characters of the segments, and named the worm *T. magna* (?). The following year (1871) Peters stated that Murie's *T. magna* was the same as his *T. gigantea*. The worm was transferred to genus *Anoplocephala* by Blanchard in 1891.

The next paper dealing with Cestodes from a Rhinoceros is that of the MacCallums (1912); they give a detailed account of the external and internal anatomy of the segments of an enormous worm at least 20 feet long passed by a Javanese rhinoceros (*R. sondiacus*). The MacCallums assume that their worm is the same as that described by Peters and Murie.

Douthitt, in his monograph of the *Anoplocephalidae* (1915) refers to the MacCallums' paper, and states that he considers the worm should be transferred to genus *Schizotaenia*.

Whether the MacCallums were correct in their inference that the worm found by them in *Rhinoceros sondiacus* is identical with those found by Peters and Murie in the African rhinoceros and Indian rhinoceros, respectively, seems to be a matter of some doubt, having consideration to the enormous difference in size, but, as neither Peters nor Murie give any detailed account of the internal anatomy of these worms, it is impossible to form any definite judgment.

It should be noted that the worm with which we are dealing conforms, as regards size, much more closely to Peters' worm than to the MacCallums'.

To avoid confusion, it appears to be best to associate the name *A. gigantea* with the worms described in detail by the MacCallums.

There is, however, no doubt that the worm with which we are dealing is different from that described by the MacCallums. The chief points of difference are shewn in the following table:—

	A. gigantea	*A. vulgaris*, n. sp.
(1) Size	More than 20 feet	Probably not more than 12 cms.
(2) Gravid uterus	A large sacculated cavity which extends laterally almost from one margin of the segment to the other	Consists of a series of apparently more or less isolated compartments which originate from ingrowths of dorso-ventral and antero-posterior muscle fibres between the limbs of a convoluted tubular uterus.
(3) Cirrus	Armed	Unarmed

I propose for this worm, which was obtained from *Rhinoceros bicornis*, the name *Anoplocephala vulgaris*, n.sp.

It should be noted that the MacCallums, both in their written description of their worm and in the illustration, have apparently confused the ovary and the vitelline glands and *vice versâ*.

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STUDIES IN THE TREATMENT OF MALARIA

XXXI.—THE TIME OF ONSET OF THE PAROXYSMS IN SIMPLE TERTIAN MALARIA

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The times recorded in the following paper are those at which a certain clinical event happened.

They are the hour,* when the patient's condition was such—shivering or feeling ill in one way or another—as to lead him to draw the Ward Sister's attention to the fact, or, on the other hand, the hour when the Sister herself noticed the patient's condition and proceeded to take his temperature, and to make a blood film.

Only those paroxysms are considered in which the temperature rose to over 100° F., and in which simple tertian parasites (*P. vivax*) were found in the blood films made at the time.

We are considering neither the exact time at which the patient's temperature began to rise nor that at which the maximum temperature was reached during the paroxysm, but simply, as already stated, the hour at which the patient's condition was such as to demand attention.

The following data in regard to the men's daily habits may be of importance in considering the causes which determine the onset of the paroxysm, although they cannot apply in certain cases to any

* *e.g.*, 2 o'clock signifies 2.00—2.59. 3 o'clock, 3.00—3.59, etc.

but the first of a series of paroxysms, as after the first paroxysm the patient was sometimes not well enough to leave his bed and take ordinary diet before one or more subsequent paroxysms had occurred :—

7 a.m.	Reveille.
8 a.m.	Breakfast.
10 to 12-30 p.m.	Goes out.
12-30 p.m.	Dinner.
1 to 4-30 p.m.	Goes out.
4-30 p.m.	Tea.
9 p.m.	Lights out.

In recording the hours at which the paroxysms were noted, it is possibly necessary to consider the fact that 'Summer time'* was in force during the years over which the observations extend, namely, 1917 when 'Summer time' began 2 a.m., 8th April, and ended 2 a.m., 17th September, and 1918 when it began 2 a.m., 24th March, and ended 2 a.m., 30th September.

As we did not know whether the change from 'Greenwich' to 'Summer' time, or rather the change in habits of life induced thereby, exerted any influence on the incidence of the paroxysms, we have grouped our observations into two periods, (1) those which occurred during the months October to March, when 'Greenwich' time was in operation, and (2) those which occurred during the months April to September, when 'Summer' time was in operation. Finally we have recorded the 'Greenwich' time of the paroxysms occurring during the months when 'Summer' time was in force.

Table I shews :—

(1) That for each winter month the maximum number of paroxysms occurred at 2 p.m. (Greenwich time), except in February, when thirteen paroxysms were recorded at 1 p.m. as against twelve at 2 p.m.

(2) That for each summer month the maximum number of paroxysms occurred at 2 p.m. ('Summer' time), and consequently,

(3) That for each summer month the maximum number of paroxysms occurred at 1 p.m. (Greenwich time).

The fact that the maximum number of paroxysms occurs at

* During 'Summer' time the clock was advanced one hour.

TABLE I.

Shewing the hours at which Simple Tertian Malaria Paroxysms occurred.

I. WINTER MONTHS : 'GREENWICH' TIME.

Hours.	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Midnight
October ...	0	0	0	0	0	1	0	2	2	0	3	1	1	7	2	3	0	1	1	1	0	0	0	0
November ...	0	0	0	0	0	0	1	2	1	3	0	0	0	4	0	0	2	1	0	0	0	2	0	0
December ...	0	1	0	0	0	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0
January ...	0	0	0	0	0	0	0	0	1	1	0	0	0	2	2	1	0	1	0	0	0	0	0	0
February ...	0	0	1	0	0	1	2	0	5	9	2	8	13	12	9	4	3	1	2	0	2	0	0	1
March ...	0	0	0	1	0	1	3	2	6	17	9	9	17	24	8	9	6	7	6	0	0	2	0	0
	0	1	1	1	0	3	6	6	15	31	14	18	32	51	21	17	11	11	9	1	2	4	0	1

II. SUMMER MONTHS : 'SUMMER' TIME.

April ...	0	0	1	0	0	0	2	7	5	16	14	20	19	22	15	11	11	8	3	1	0	1	0	1
May ...	0	0	0	0	1	0	2	2	4	3	7	12	16	31	24	14	6	11	3	1	1	0	0	0
June ...	0	0	0	2	0	3	3	6	6	13	15	10	16	33	13	11	4	6	3	1	0	0	0	0
July ...	2	0	1	0	0	3	1	5	6	10	13	15	16	18	12	16	14	7	3	1	0	0	0	0
August ...	0	0	0	0	1	1	3	0	2	2	7	9	8	19	17	9	3	7	1	1	3	0	0	1
September ...	0	0	0	0	0	0	0	2	3	10	7	4	3	13	11	4	4	4	0	2	0	0	0	0
	2	0	2	2	2	7	11	22	26	54	63	70	78	136	92	65	42	43	13	7	4	1	0	2

III. SUMMER MONTHS : 'GREENWICH' TIME.

April ...	0	1	0	0	0	2	7	5	16	14	20	19	22	15	11	11	8	3	1	0	1	0	1	0
May ...	0	0	0	1	0	2	2	4	3	7	12	16	31	24	14	6	11	3	1	1	0	0	0	0
June ...	0	0	2	0	3	3	6	6	13	15	10	16	33	13	11	4	6	3	1	0	0	0	0	0
July ...	0	1	0	0	3	1	5	6	10	13	15	16	18	12	16	14	7	3	1	0	0	0	0	2
August ...	0	0	0	1	1	3	0	2	2	7	9	8	19	17	9	3	7	1	1	3	0	0	1	0
September ...	0	0	0	0	0	0	2	3	10	7	4	3	13	11	4	4	4	0	2	0	0	0	0	0
	0	2	2	2	7	11	22	26	54	63	70	78	136	92	65	42	43	13	7	4	1	0	2	2

1 p.m. (Greenwich time) in the summer months, *i.e.*, an hour earlier than in the winter months, may be explained on one of two assumptions:—

(1) That paroxysms actually occur earlier in the summer months than in the winter months, or

(2) That the change in habits of the patient, *e.g.*, getting up an hour earlier, has induced a corresponding change in the incidence of the paroxysms.

We incline to the latter view, and hence in constructing a graph of the paroxysms we combine the figures for the winter months (Greenwich time) with the figures for the summer months ('Summer' time).

If we divide the twenty-four hours into two periods, viz., (*a*) 7 a.m. to 6-59 p.m., period of activity, and (*b*) 7 p.m. to 6-59 a.m., the period of rest, and determine the number of paroxysms which occur during each, we find, as is shewn in Table II, that 93·5 per cent. occur during the day and only 6·5 per cent. during the night.

TABLE II.

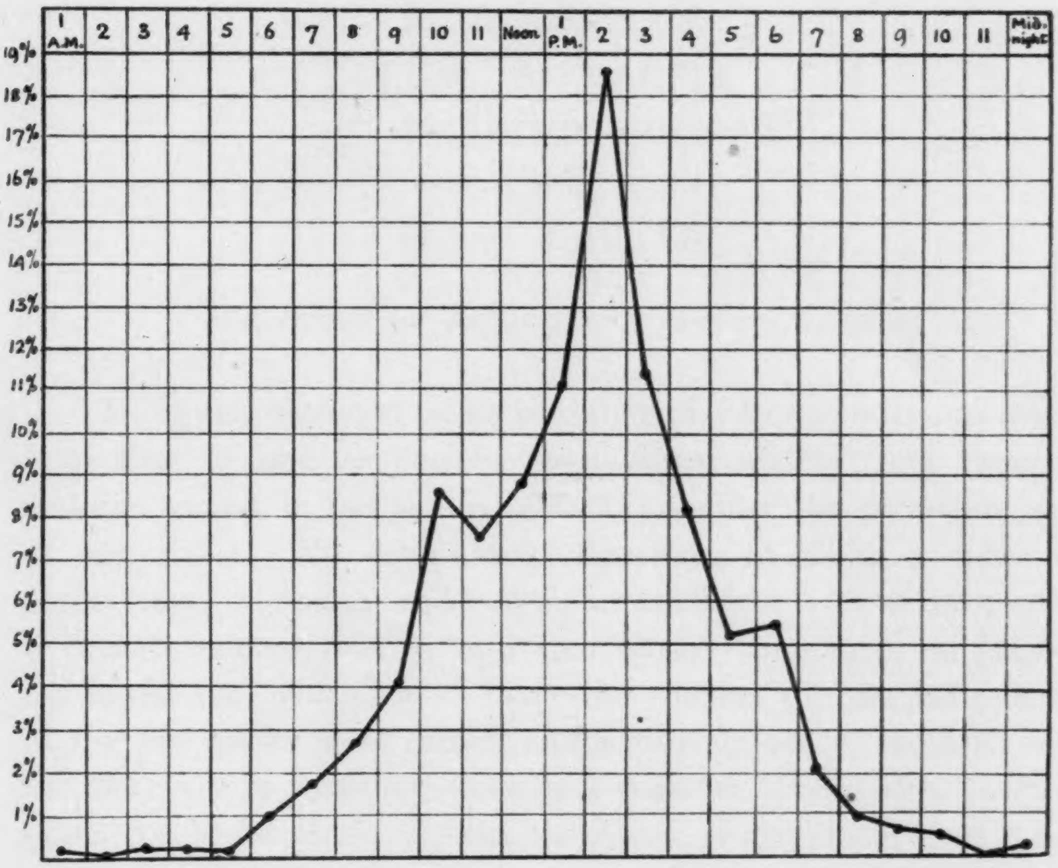
Period.	Number of Paroxysms.		
	Winter Months ('Greenwich' time)	Summer Months ('Summer' time)	Total.
7 a.m. to 6.59 p.m.	233	702	935
7 p.m. to 6.59 a.m.	23	42	65

CONCLUSIONS

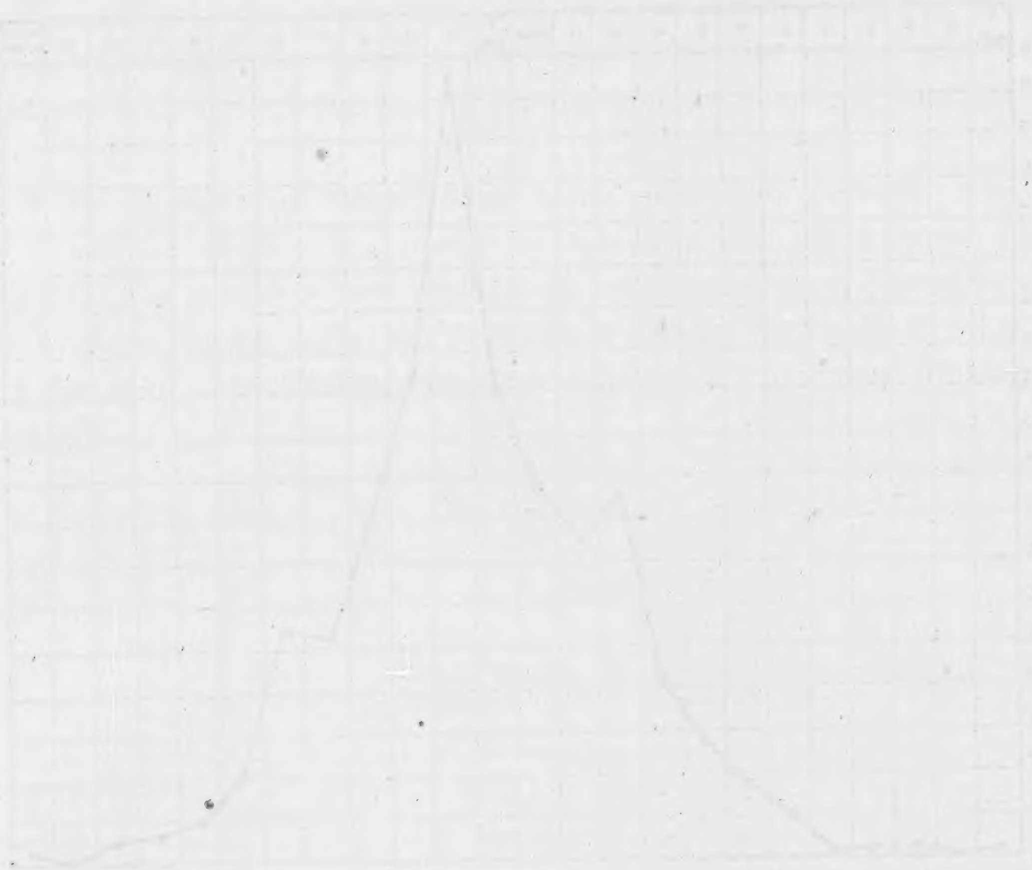
1. Over 90 per cent. of the paroxysms in simple tertian malaria occur during the hours of activity: in this series 7 a.m. to 6-59 p.m.

2. The maximum number of paroxysms under these conditions of activity occurred at 2 p.m.

3. Alteration of the period of activity by one hour, the result of the adoption of 'Summer time' produced a corresponding alteration in the time of incidence of the paroxysms.



GRAPH.—Showing the time incidence of 1,000 simple tertian malaria paroxysms; 'Summer' time in operation.



HAVE DIFFERENTIAL LEUCOCYTE COUNTS ANY VALUE?

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The figures obtained by us in differential leucocyte counts made from time to time on various blood films, mainly from cases of malaria, raised in our minds a doubt whether the procedure was of any value. We determined, therefore, to make a series of observations on normal and non-malarial bloods. As we proceeded it became evident that we must relinquish—temporarily at least—our initial aim, which was to determine whether the 'normal values' of the text-books were correct and substitute for it another, viz., the discovery of a method whereby a constant result (within certain limits) could be obtained from the blood of any individual. As, moreover, we did not know where the errors—which we felt certain existed—arose, whether, for instance, in the blood drop itself, in the making of the film, in the part of the film counted, in the process of counting, or in a combination of two or more of these possible sources of error, it was only gradually that order came out of our observations. In recording these observations, we have re-arranged them in the way that we consider will best illustrate some of the factors that must be taken into account.

Reflection shews that a differential leucocyte count can only be of value if the following conditions are satisfied.

1. That the portion of the film counted is of the same

composition as the rest of the film, or of the same composition as corresponding portions of the film. For example, if the count is made along an edge, the portion counted should at least give the same result as any other portion of the edge. In other words, we must be assured that the particular portion counted is representative of the whole film, or at least of definite zones of the film. All errors on this point could, of course, be eliminated by counting the whole film, but as a routine procedure this is impossible, as ordinary films may contain some 5,000 leucocytes, the counting of which would not only take several hours, but would be, as we shall show presently, a matter of extreme difficulty.

2. That the blood which issues from the puncture is of the same composition as that in the vessels, *i.e.*, that various drops from various punctures of a single individual made at the same time are of identical composition.

These two fundamental conditions mean that the portion of the film counted must be representative of the blood on the film, and that the drop from which the film is made must be representative of the blood in the vessels; and it is clear that if they are not fulfilled the count is of no value.

3. That the 'normal values' of the text-books are correct, otherwise there is no standard with which any leucocyte count can be compared.

We may state at once that we have not been able to discover how these 'normal values' have been ascertained.

In order to find out how far these conditions hold good, we shall proceed to record a series of differential leucocyte counts made by ourselves.

METHOD EMPLOYED FOR MAKING BLOOD FILMS

Except when otherwise stated, the following technique was employed. A puncture was made with a surgical needle, and a drop of the blood issuing was taken on to a slide near one end. With the edge of another narrower slide (the spreader), held at an angle of about 45°, contact was made with the blood drop which by capillarity flowed along the angle between the two slides. The

spreader was then pushed steadily forward towards the other end of the slide, drawing the blood behind it so as to produce a thin uniform film (fig. 1), which was then fixed and stained with Leishman's stain in the usual way.

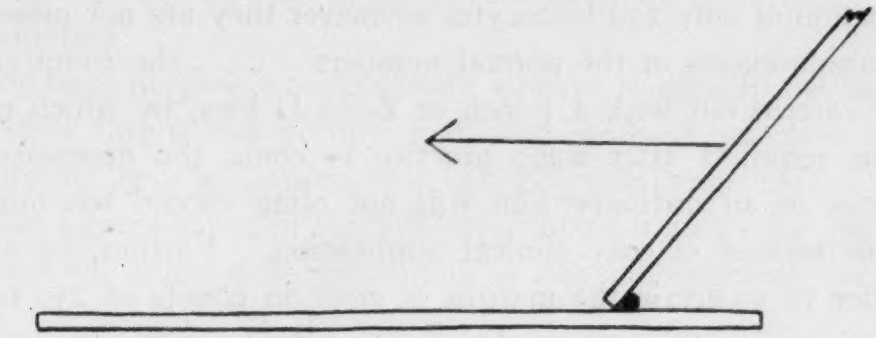

FIG. 1. Illustrating method employed for making blood films.

We will now consider some of the factors which may influence the count and be responsible for inconstant results.

THE DISTRIBUTION OF LEUCOCYTES IN A FILM

Not very much or very precise information on this important question is to be found in the literature. Rogers (1908), referring to films spread with a needle, writes, 'An excess of polynuclears and eosinophiles, and to a less extent of large mononuclears, will be found along either edge and in the distal tags marked PP (in fig. 2),

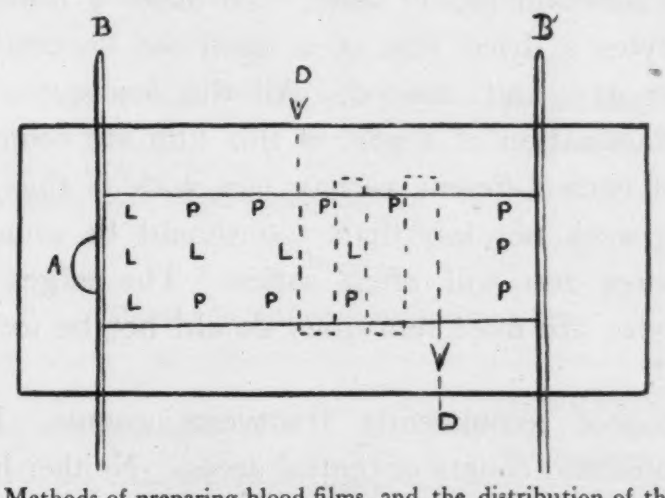

FIG. 2. Methods of preparing blood films, and the distribution of the various kinds of leucocytes in them. (After Rogers.)

while the lymphocytes will preponderate at the proximal end and in the central portions remote from either edge as indicated by the

letters LL. I have found, however, that by excluding the extreme ends of the films, and counting backwards and forwards across the intermediate portion between the dotted lines from edge to edge, very accurate percentages can be obtained by the enumeration of only 250 leucocytes whenever they are not present in considerable excess of the normal numbers . . . . the count can be readily carried out with a $\frac{1}{8}$-inch or Zeiss D lens, by which means the time required after some practice to count the necessary 250 leucocytes in an ordinary film will not often exceed ten minutes, and thus become of easy clinical application.' Further, he writes, 'In order to ascertain the margin of error in counts of 250 to 500 leucocytes under different conditions, I worked out the percentages, after enumerating varying numbers in a long series of cases, with the following results. When the total number of leucocytes was approximately normal, counts of 250 and 500 respectively made in the manner just described gave variations of under 2 per cent in any of the four kinds; . . . . When, however, a leucocytosis was present the error from a similar count might amount to 2 or 3 per cent.' It must be noted that Rogers counts his leucocytes with a dry lens, and not with an oil immersion; his definition of a large mononuclear leucocyte is based solely on size, *i.e.*, one 'fully as large or larger than an average polynuclear.' Such a procedure is open to criticism, but we are not here concerned with this matter. Daniels and Newham (1911) state, 'To make a differential count of the leucocytes a dried film of a small but uncertain volume of blood is prepared and stained. All the leucocytes found in a systematic examination of a part of this film are counted, and the percentage of each different variety met with is thus ascertained. For accurate work not less than 500 should be counted, but for clinical purposes 200 will often suffice. The edges of the film where leucocytes are most numerous should not be included in the enumeration.'.

While Rogers recommends transverse counts, Daniels and Newham recommend counts of central areas. Neither has, however, demonstrated that the particular method which he favours gives results which most closely approximate the actual result which would be obtained by counting all the leucocytes in the film: and, moreover, it is clear that if different results are to be obtained by

different methods of counting, then it is useless to compare figures obained by the method recommended by Rogers with those obtained by the method recommended by Daniels and Newham.

These points appear to us to be among the first which require examination.

We have purposely avoided any attempt to classify the leucocytes into their various sub-groups, and have confined ourselves solely to classifying them as mononuclear and polymorphonuclear.

The figures given in the following tables indicate the percentage of the total leucocytes constituted by the mononuclear variety—in short, the mononuclear percentage.

EXAMINATION OF THE WHOLE OF A SMALL FILM

The whole of two small films was examined and the mononuclear percentage determined for the various areas into which they were ruled, as is shewn in figs. 3 and 4.

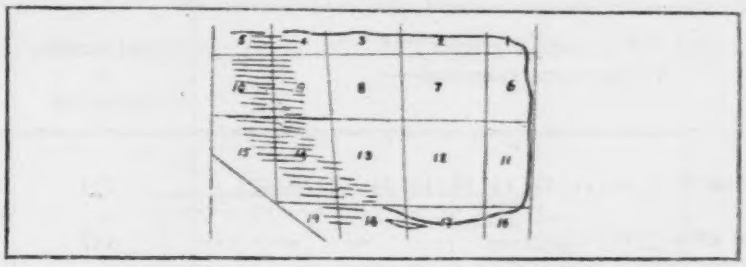

FIG. 3. Shewing areas into which the blood film was ruled.

EXPERIMENT I.

a. Blood of normal adult (S.M.) who has been in the tropics and who has had malaria.
b. Blood taken from dorsum of finger.
c. Counts made by a single observer.

TABLE I.

Shewing distribution of leucocytes in a film.

Various areas examined	Total number of leucocytes.	Mononuclear percentage
1. Central areas (7, 8, 12, 13)	185	45·0
„ including part 'tongue' areas (7, 8, 9, 12, 13, 14)	374	41·0
2. Transverse areas (2, 7, 12, 17, 3, 8, 13, 18)	375	39·0
3. Edge areas (1-5, 16-18)	162	29·6
4. 'Tongue' areas (5,10, 15, 19)	972	25·7
5. Total film 1-19	1660	30·6

EXPERIMENT IA.

a—c as in Experiment I.

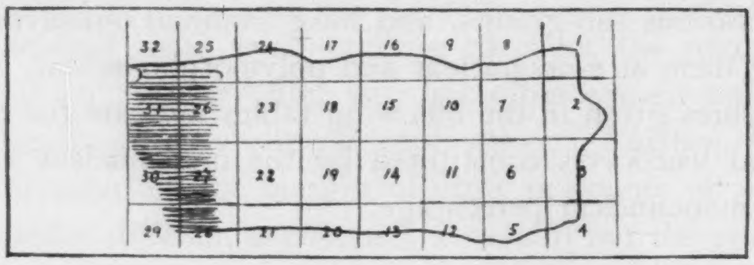

FIG. 4. Shewing areas into which the blood film was ruled.

TABLE IA.

Distribution of leucocytes in a film.

	Various areas examined	Total number of leucocytes	Mononuclear percentage
1.	Central areas (6, 7, 10, 11, 14, 15, 18, 19, 22, 23, 26, 27) ...	274	48·2
2.	Transverse areas (5-28)	547	39·8
3.	Edge areas (1, 8, 9, 16, 17, 24, 25, 4, 5, 12, 13, 20, 21, 28)	290	32·8
4.	'Tongue' areas (29-32)	622	20·4
5.	Total film 1 to 32	1252	29·6

These observations shew:—

1. That the mononuclear percentage is highest in the central areas of a film and lowest in the tongue areas; the edge areas give a figure which is intermediate.

2. That the mononuclear percentage found in the edge areas approximates most closely to that found in the total film.

EXAMINATION OF DIFFERENT AREAS OF ORDINARY (LARGE) FILMS

In this series of observations on ordinary films, no attempt was made to count all the leucocytes in the film, but a definite number only were examined in certain areas which in this and in the succeeding observations may be defined as follows:—

Edge areas. Areas bounded by the edges of the film and imaginary lines parallel to them at a distance from the edges equal to that of the diameter of the microscope field given by a 1/12 oil immersion lens and a 4 ocular.

Central areas. The part of the film lying between the edge areas.

Transverse areas. Composite areas embracing the former areas, the counts being made by examining the slide methodically from edge to edge.

In all cases, as shewn in fig. 5, two lines were drawn across the film excluding the commencement and tongues of the film respectively: all the counts were made between these two lines.

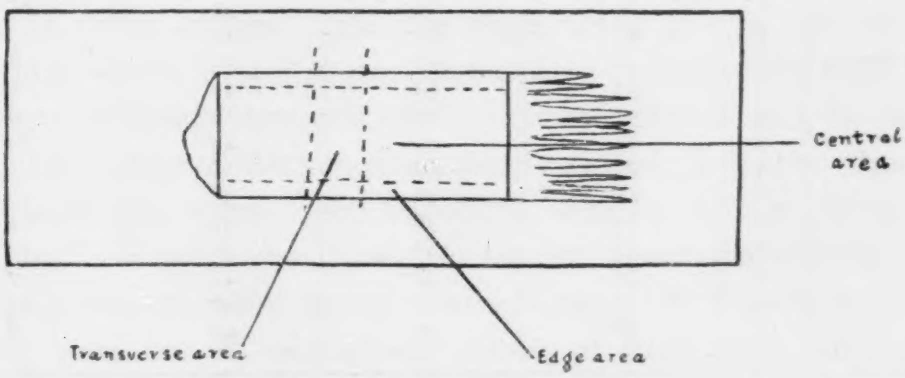

FIG. 5. Shewing various areas of a blood film.

EXPERIMENT II.

a. Blood of 4 patients: dysentery (1), myalgia (1), and trench fever (2).

b. Blood from ear spread with a needle.

c. A film was made from each of the patients on a number of consecutive days, as shewn in the table, making in all 34 films.

d. A count made by a single observer.

e. 250 leucocytes counted in each area.

TABLE II.

Shewing results obtained by counting 250 leucocytes in different areas of the same films.

Case	Days	Central areas	Transverse areas	Edge areas	Range
Dysentery ...	1	62	57	54	8
	2	56	55	53	3
	3	65	54	61	11
	4	58	53	54	5
	5	60	59	42	28
	6	60	56	46	14
	7	72	58	60	14
	8	64	66	66	22
Myalgia ...	1	45	43	38	7
	2	41	58	46	17
	3	59	53	41	18
	4	51	64	51	13
	5	62	52	50	12
	6	42	46	38	8
	7	56	47	43	13
	8	47	50	49	23
Trench fever ...	1	53	45	50	8
	2	63	47	43	20
	3	52	48	44	8
	4	43	45	35	10
	5	56	46	44	12
	6	59	52	34	25
	7	47	47	42	5
Trench fever ...	1	47	47	39	8
	2	43	42	41	2
	3	58	49	50	9
	4	58	44	43	19
	5	63	60	58	5
	6	48	52	38	10
	7	55	56	52	4
	8	53	46	46	7
	9	35	42	40	7
	10	35	20	26	15
	11	38	46	42	8

It is seen from Table II that the central areas gave a higher mononuclear percentage than the edge areas of the same film in twenty-eight of thirty-four instances, an equal percentage in one instance, and a lower percentage in five. In about half the cases the mononuclear percentage of the transverse area was intermediate between those for the central and edge areas of the same film.

EXPERIMENT III.

a. Blood of normal adult.
b. Blood taken from ear and spread with a needle.
c. A film was made on each of five consecutive days.
d. Count made by a single observer.
e. 1,000 leucocytes counted in each area.

TABLE III.

Shewing results obtained by counting 1000 leucocytes in different areas of the same films.

Days	Central areas	Transverse areas	Edge areas	Range
1	47	46	40	7
2	65	61	54	11
3	61	...	47	14
4	51	...	44	7
5	52*	...	42*	10

* 500 leucocytes only counted.

In this series of observations the highest mononuclear percentage was found in the central areas and the lowest in the edge areas in each case; the transverse areas were intermediate.

Consideration of the results of these earlier experiments shews that in a blood film the distribution of leucocytes, in respect of mononuclear percentage, is irregular. The mononuclear percentage is lowest in the tongue areas and increases as we pass from the edge areas to the transverse areas, and reaches its maximum in the central areas; of these various areas the edge areas give a mononuclear percentage which approximates most closely to that of the total film. This fact is clearly brought out in Experiments I and IA, where all the leucocytes in the two films were counted; it is also shown in Experiment III, where 1,000 leucocytes were counted in the various areas; but in Experiment II, where only 250 leucocytes were counted, the result was to some extent contradictory. It follows from this that for purposes of comparison, counts of edge areas only, or of transverse areas only, can be used. As edge areas give a mononuclear percentage which approximates most closely to that of the total film, and as they are more easily and rapidly counted than transverse or central areas, it appears desirable to confine the counts to these areas.

In view of the fact that counts of 250 fail to demonstrate the fact that the mononuclear percentage of edge areas is less than that of central or transverse areas, they are of no value. Further evidence of the inconstant results obtained by 250 counts is given by the following experiments.

EXPERIMENT IV.

a. Blood of healthy adult C., who had never been out of England.
b. Blood taken from dorsum of finger.
c. Films made from 1st and 5th drops issuing from puncture at 12.30 p.m. and also at 2.30 p.m. for five consecutive days.
d. 250 leucocytes counted by each of six observers.
   i. Edge counts.
   ii. Transverse counts.

TABLE IV.

Shewing results obtained by six observers each counting 250 leucocytes in edge and transverse areas of each of a number of films made at different times from one individual.

Days	Times	Drop	Edge counts: Average counts of six observers	Edge counts: Maximum	Edge counts: Minimum	Edge counts: Range	Edge counts: Greatest variation from average	Transverse counts: Average counts of six obersvers	Transverse counts: Maximum	Transverse counts: Minimum	Transverse counts: Range	Transverse counts: Greatest variations from average
1	12.30	1st	39	42	35	7	4	50	54	38	16	12
		5th	41	45	37	8	4	43	48	39	9	5
	2.30	1st	31	33	30	3	2	43	48	38	10	5
		5th	29	32	26	6	3	40	44	38	6	4
2	12.30	1st	28	30	26	4	2	44	52	40	12	8
		5th	28	30	27	3	2	44	51	42	9	7
	2.30	1st	29	34	26	8	5	40	46	35	11	6
		5th	32	36	26	10	6	39	43	36	7	4
3	12.30	1st	41	43	37	6	4	51	62	46	16	11
		5th	29	32	27	5	3	48	53	46	7	5
	2.30	1st	30	33	28	5	3	44	49	39	10	5
		5th	36	45	32	13	9	49	55	39	16	10
4	12.30	1st	38	39	30	3	2	43	46	37	9	6
		5th	40	44	38	6	4	43	48	37	11	6
	2.30	1st	38	39	37	2	1	47	56	40	16	9
		5th	30	31	30	1	1	48	52	39	13	9
5	12.30	1st	44	46	42	4	2	49	56	46	10	7
		5th	37	38	34	4	3	50	56	40	16	10
	2.30	1st	39	40	37	3	2	51	55	48	7	4
		5th	35	37	32	5	3	45	47	42	5	3

EXPERIMENT IVA.

a. Blood of healthy adult M., who had never been out of England.
b-d. As in Experiment IV.

TABLE IVA.

Shewing the results obtained by six observers each counting 250 leucocytes in edge and transverse areas of each of a number of films made at different times from an individual

Days	Times	Drop	Edge counts: Average counts of six observers	Edge counts: Maximum	Edge counts: Minimum	Edge counts: Range	Edge counts: Greatest variation from average	Transverse counts: Average counts of six observers	Transverse counts: Maximum	Transverse counts: Minimum	Transverse counts: Range	Transverse counts: Greatest variation from average
1	12.30	1st	34	37	32	5	3	47	51	42	9	5
		5th	38	40	37	3	2	51	57	46	11	6
	2.30	1st	41	45	39	6	4	47	49	41	8	6
		5th	34	36	31	5	3	49	57	40	17	9
2	12.30	1st	42	45	40	5	3	47	50	40	10	7
		5th	39	43	34	9	5	46	52	40	12	6
	2.30	1st	45	47	42	5	2	48	56	44	12	8
		5th	37	38	35	3	2	49	54	42	12	7
3	12.30	1st	42	44	38	6	4	45	48	35	13	10
		5th	38	40	36	4	2	51	56	48	8	5
	2.30	1st	37	41	34	7	4	38	44	35	9	6
		5th	39	43	37	6	4	47	52	40	12	7
4	12.30	1st	40	46	35	11	6	54	58	50	8	4
		5th	41	44	36	8	3	50	57	43	14	7
	2.30	1st	41	44	35	9	6	55	60	52	8	5
		5th	38	40	35	5	3	48	50	46	4	2
5	12.30	1st	43	46	39	7	4	51	57	47	10	6
		5th	37	38	34	4	3	50	52	46	6	4
	2.30	1st	28	30	27	3	2	42	46	40	6	4
		5th	40	42	38	4	2	50	54	48	6	4

If we compare the results of the 250 counts obtained by each of the six observers for the same areas of the same films, we find very great variations. In the case of the edge areas the greatest range between the counts of the six observers for the same films were in the two cases respectively 13 and 11, and the maximum variations from the average of the six counts 9 and 6: in the transverse areas the ranges were respectively 16 and 17, and the maximum variation from the average 12 and 10. These variations are so great that it is obvious that they must be explained before proceeding any further.

The number of leucocytes comprising the individual count of each observer was only 250; it is hardly possible that in any film two observers counted exactly the same leucocytes, in fact, in some instances the 250 leucocytes counted by one observer were entirely different from those counted by another. For example, one observer examines one edge of the film and another the other edge, or if they both examine the same edge they begin at different ends; this applies also in the case of transverse counts. It is possible, therefore, that the ranges in the individual counts may be due to the fact that different leucocytes were examined.

Another possibility is that the same leucocytes were differently interpreted by different individuals. Finally, the differences may be the result of a combination of these two factors.

In order to investigate the problem, minute blood films of the same two individuals were made, and all the leucocytes present in them were examined by a number of different observers. To ensure that every leucocyte was counted once, and once only, a small square aperture was cut in a disc of gelatine, which was inserted into the ocular; by means of a mechanical stage the whole film was then passed in regular sequence under the square field.

Experiment V.

a. Blood of healthy adult C., who had never been out of England.
b. Blood taken from dorsum of finger.
c. Minute blood films made from 1st and 5th drops issuing from puncture at 12.30 p.m. and 2.30 p.m. on two days.
d. The whole of each film counted by five observers.

Experiment Va.

a. Blood of healthy adult M., who had never been out of England.
b—d. As in Experiment V.

TABLES V AND VA.

Case	Date	Time	Drop No.		Results obtained by the five observers: M.	C.	S.	B.	Co.	Average of results obtained by five observers	Range	Greatest variation from the average
C	Jan. 10	p.m. 12.30	1st	T.L.	205	205	196	203	217	205	21 (10·2%)*	
				M. %	43·9	45·4	42·8	39·9	43·7	43·1	5·5	3·2
			5th	T.L.	247	248	242	257	257	250	15 (6%)	
				M. %	48·6	50·0	47·9	45·9	47·9	48·1	4·1	2·2
		2.30	1st	T.L.	465	459	429	455	460	453·6	36 (7·9%)	
				M. %	33·8	32·3	32·1	31·8	34·1	32·8	2·3	1·3
			5th	T.L.	513	519	525	521	522	520	12 (2·3%)	
				M. %	34·1	34·3	34·8	33·2	35·6	34·4	2·4	1·2
	Jan. 15	12.30	1st	T.L.	167	162	166	164	170	165·8	8 (4·7%)	
				M. %	40·7	42·0	42·1	40·8	41·1	41·3	1·4	0·8
			5th	T.L.	158	155	161	153	162	157·8	9 (5·7%)	
				M. %	43·7	45·2	42·2	45·7	43·2	44·0	3·5	1·8
		2.30	1st	T.L.	203	205	186	191	205	198	19 (9·5%)	
				M. %	37·4	38·1	37·1	36·6	32·6	36·4	5·5	3·8
			5th	T.L.	264	269	254	254	279	264	25 (9·5%)	
				M. %	31·4	33·1	32·6	32·0	32·2	32·3	1·7	0·9
M	Jan. 10	p.m. 12.30	1st	T.L.	262	261	251	271	261	261·2	20 (7·6%)	
				M. %	37·0	38·4	38·9	36·1	36·4	37·5	2·8	1·4
			5th	T.L.	103	101	105	105	104	103·6	4 (3·8%)	
				M. %	37·9	40·6	41·9	39·0	38·4	39·6	4·0	2·3
		2.30	1st	T.L.	208	212	208	216	205	209·8	11 (5·2%)	
				M. %	40·8	40·1	39·4	39·3	39·0	39·7	1·8	1·1
			5th	T.L.	555	559	565	522	563	552·8	43 (7·7)	
				M. %	34·6	35·1	35·0	34·8	35·5	35·0	0·9	0·5
	Jan. 15	12.30	1st	T.L.	148	142	144	142	144	144	6 (4·2%)	
				M. %	36·5	35·9	35·5	35·2	34·7	35·6	1·8	0·9
			5th	T.L.	103	97	90	91	96	95·4	13 (13·6%)	
				M. %	41·7	46·3	45·5	39·5	38·5	42·3	7·8	4·0
		2.30	1st	T.L.	150	147	142	144	149	146·4	8 (5·5%)	
				M. %	26·0	27·3	28·8	26·3	28·8	27·4	2·8	1·4
			5th	T.L.	138	134	127	121	120	128	18 (14·1%)	
				M. %	21·7	23·9	23·6	20·8	21·6	22·3	3·1	1·6

* The figures in brackets represent the range expressed as a percentage of the actual total (average of five observers).

T.L. = Total Leucocytes in film. M. % = Mononuclear percentage.

In none of the sixteen films in Experiments V and VA did more than two observers agree as to the total number of leucocytes present. The range between highest and lowest total count varied in the case of the different films from 2·3 to 14·1 per cent. of the actual total (average of five observers) for the corresponding film.

This failure to agree on the exact number of leucocytes in a film may at first sight be rather surprising, but the procedure is not so simple as it may appear. The following seem to us to be some of the causes most likely to produce the discrepancy:—

1. Failure to pass the whole film under review once, and once only, due to defective action of the mechanical stage, which would result in portions of the film being either omitted or re-observed.

2. The end portion of a film consists of small tongue-like prolongations and minute islands, and possibly some of the latter escaped the observation of certain of the observers.

3. In the process of making the minute films, a number of leucocytes are damaged, and fragments which may be omitted from the counts of one observer as unrecognisable may be sufficiently identified by another for inclusion. Or again, if a leucocyte is split into two approximately equal portions, which become separated one from the other, the fractions may be both omitted by one observer or counted as two leucocytes by another.

Whatever the reasons for the discrepancy may be, the fact remains that we did not succeed in accomplishing what we hoped to do, viz., making certain that an opinion was passed once, and once only, on every leucocyte in a film by each of the five observers. Having failed to do this, we are not in a position to ascertain absolutely the amount of error arising from the personal factor of interpretation. However, as the figures given by each observer for the total leucocyte count are comparatively close, we can reasonably infer that whatever the actual totals in the various films were, a very large percentage of the leucocytes in each film had been examined by each observer once, and once only, and that, therefore, the figure for the mononuclear percentage was obtained by each observer from an examination of practically the same leucocytes.

It will be seen from Table V that the maximum range in mononuclear percentage obtained by the five observers examining the same film were in the two cases respectively 5·5 and 7·8, while

the maximum variations from the actual mononuclear percentage (average of the five observers) were 3·8 and 4·0.

In view of the fact mentioned above that the different observers were not dealing with exactly the same leucocytes, these discrepancies cannot be explained altogether by error of interpretation, although it is probable that the personal factor is partly responsible. It must, however, be recognised that the personal factor of interpretation is subjected to a much more severe (possibly hardly fair) test in the case of total counts of minute films than in counts of selected areas of ordinary (large) films. It will be remembered that in dealing with ordinary films, the two ends (commencement and tongues) were ruled off and excluded from the counts, whereas in the case of total counts of the minute films, both commencement and tongues of the film are necessarily included: it is at these extremities of the film that the greatest difficulty of interpretation is experienced, because the commencement of the film is usually its thickest portion and the tongue areas contain the greatest proportion of damaged leucocytes.

Notwithstanding these considerations, the maximum variation from the actual mononuclear percentage obtained by any of the observers in the sixteen minute films is only 4, which is relatively small when compared with 9 for the forty edge counts and with 12 for the forty transverse counts in Experiment IV and IV*a*, showing clearly that the more carefully we arrange that the different observers examine the same leucocyte the more closely do the results obtained by the different observers approximate.

We infer from this, that the errors arising from differences of interpretation are relatively small, and can in no way explain the large differences obtained by the various individuals in examining the edge and transverse areas of the same films in Experiments IV and IVA; we are, therefore, forced to conclude that the explanation of the discrepancies is that they are due in the main to the fact that the different observers examined different leucocytes. In other words, it appears that the distribution of leucocytes as regards mononuclear percentage is so irregular in both the edge and transverse areas, that samples of 250 are far too small to give constant results for the same edge or transverse areas.

We next decided to ascertain whether more constant results could

be obtained from large counts, *e.g.*, 500, 1,000, 2,000, 4,000, etc. As there is only a limited number of leucocytes in the edge areas or transverse areas of any film, it is clear that a number of films must be used for such large counts. This may be done, provided we are certain that the constitution of the blood on the various films is identical. A difficulty at once arises, because we have no knowledge that various drops issuing from the same puncture are identical in composition, and still less that drops issuing from different punctures are of the same composition. However, for the purpose of the next experiment, we have assumed that when blood is issuing freely from a puncture, successive drops are of the same constitution.

EXPERIMENT USING SUCCESSIVE DROPS OF BLOOD FLOWING FREELY FROM SAME PUNCTURE

Experiment VI.

a. Blood of normal adult S.M., who has been in tropics and who has had malaria.
b. Blood of dorsum of finger.
c. Deep puncture made and free flow of blood obtained.
d. Films made from drops 7-10, 13-16, 19-22, and 25-28 (sixteen films).
e. Four observers each count a separate film in each set.
f. 500 leucocytes counted by each observer.
g. Edge areas (excluding tongues).

Experiment VIa.

a. Blood of normal adult Y., who has been in tropics and who has had malaria.
b.-g. As in Experiment VI.

Tables VI and VIa shew that in counts of edge areas of films made from successive drops of blood freely flowing from the same puncture, the range obtained when 500 leucocytes are counted was in the two cases M. and Y. respectively 11 and 10, and when 1,000 were counted 6·5 and 5·7. The greatest variation from the figure obtained by counting 8,000 leucocytes was in the 500 counts 8 and 6 respectively in the two cases, and in the 1,000 counts 4 and 3·25. If we assume that the successive drops of blood flowing freely from the same puncture are of constant composition, then from the above experiment it follows that if only 500 leucocytes are counted, the result obtained may be as much as 8 above or 8 below the 'true figure' obtained by the

8,000 counts, and if 1,000 leucocytes are counted the result may be as much as 4 above and 4 below the 'true figure.' Consequently, differences as great as 16 obtained in edge counts of 500 leucocytes and as great as 8 in edge counts of 1,000 leucocytes do not necessarily mean that the mononuclear percentage in the various bloods concerned is actually different.

These preliminary experiments which deal solely with attempts to determine the mononuclear percentage of the blood of normal persons suffice, we think, to shew that considerable difficulties surround what has hitherto been regarded as a simple matter.

TABLE VI.

Experiment with successive drops of free flowing blood from same puncture to shew variation obtained by counts of 500 and 1000 respectively.

No. of drop	Observer	Results of 500 counts	Range of eight counts of 500	Results of 1000 counts	Range of eight counts of 1000	Results of 8000 counts	Maximum variation from result of 8000 count obtained by	
							500 count	1000 count
7	S.	32	11	32·5	6·5	31	8	4
8	M.	33						
9	C.	29		30·0				
10	Y.	31						
13	S.	31		35·0				
14	M.	39						
15	C.	32		30·0				
16	Y.	28						
19	S.	32	10	33·5				
20	M.	15						
21	C.	31		29·5				
22	Y.	28						
25	S.	25		28·5				
26	M.	32						
27	C.	29		29·0				
28	Y.	29						

TABLE VIA.

Experiment with successive drops of free flowing blood from same puncture to shew variation obtained by counts of 500 and 1000 respectively.

No. of drop	Observer	Results of 500 counts	Range of eight counts of 500	Results of 1000 counts	Range of eight counts of 1000	Results of 8000 count,	Maximum variation from result of 8000 count obtained by 500 count	1000 count
7	S.	50·0	8	54·0	5·75	52	6	3·25
8	M.	58·0						
9	C.	53·5		53·25				
10	Y.	53·0						
13	S.	52·0		52·0				
14	M.	52·0						
15	C.	51 0		51·0				
16	Y.	51						
19	S.	51	10	51·5				
20	M.	52·0						
21	C.	52·5		55·25				
22	Y.	58·0						
25	S.	49·0		49·5				
26	M.	50·0						
27	C.	55·0		51·5				
28	Y.	48·0						

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PRELIMINARY NOTE ON THE DEVELOPMENT OF THE LARVAE OF *DIROFILARIA IMMITIS* IN DOG FLEAS *CTENOCEPHALUS FELIS* AND *CANIS*

BY

A. BREINL

From the Australian Institute of Tropical Medicine, Townsville

(*Received for publication* 11 *January*, 1921)

Dirofilaria immitis (Blanchard 1895) is a parasite commonly found in dogs in and around Townsville, and a number of the animals succumb to the infection with this parasite under similar clinical symptoms to those described from other parts of the world. Microfilariae can usually be seen in the peripheral blood of the infected animals at any hour of the day or night.

The transmission of *Dirofilaria immitis* by mosquitoes has been definitely proved by several writers, and the parasite undergoes its full development of cycle in mosquitoes belonging to such different genera as *Stegomyia*, *Anopheles* and *Culex*.

The fact that this parasite does not require a definite genus of mosquito for the successful completion of its life history, as definitely proved for the majority of protozoal infections, suggested further investigations to ascertain whether other ectoparasites of dogs, such as fleas, offer suitable conditions for the development of the larvae of *Dirofilaria immitis*, when taken up in the infected blood by the fleas.

T. L. Bancroft in Australia, and others in different parts of the

world, have suspected *Pulex serraticeps*, but were unable to trace further development of the larvae after the blood containing them was digested.

Fleas were collected from dogs known to harbour the parasite in their peripheral blood, and were dissected in the usual way. As a rule, *Ctenocephalus canis* and *felis* occurred in about the same proportion, but at other times the number of *C. felis* much preponderated. The terminal segment of the flea was snipped on both sides, and by gentle traction the proventriculus, mid-gut and hind-gut with the Malpighian tubes were removed as a whole.

The alimentary canal was teased out on a slide in a small quantity of saline, and the specimen thus obtained fixed before drying in a fixing solution containing equal parts of concentrated picric acid and mercuric chloride, to which acetic acid was added to make it up to a 4 per cent. solution. The films were fixed for a few minutes in this solution, hardened in alcohol of increasing strength and afterwards stained with Ehrlich's haematoxylin. A number of other stains were experimented with, but the results were in no case superior to that obtained with haematoxylin. We were thus able to obtain 'wet' films, which, on microscopical examination, showed structural details not seen in dried specimens.

Whilst dissecting fleas, it was noticed on several occasions that when teasing out the alimentary canal large nematodes escaped from the body cavity which were actively motile, and could not be differentiated from mature filarial larvae such as seen in the infected mosquito.

Fleas collected from an infected dog which contained fresh blood, more or less altered, in their mid-gut, showed, as a rule, filarial larvae in a varying quantity resembling closely the forms seen in the peripheral blood of the dog. In addition, forms were seen with a slightly broadened posterior end (measuring in the stained specimens 6μ to 8μ), whereas the diameter at the anterior end measured about 4μ to 5μ. In many instances the Malpighian tubes of 'infected' fleas contained parasites further developed: small stumpy forms about 90μ to 120μ long and 14μ to 16μ broad with a pointed tail end, longer forms up to 250μ and more in length and up to 30μ in width; in addition, many intermediate stages were seen on different occasions. The large, free

forms up to 600μ in length and 20μ to 30μ wide were found now and again free in the body cavity of the flea.

Our experience has thus shown that the larvae of *Dirofilaria immitis* undergo a complete developmental cycle, analogous to that in the mosquito (*Stegomyia fasciata* was used in our experiments) in the dog fleas, *Ctenocephalus canis* and *felis*. The larvae enter the flea with the blood and obtain access to the Malpighian tubes, where the further development takes place. When nearly mature they leave the Malpighian tubes, and are found free in the body cavity.

It was noted that the degree of development depended greatly on the external temperature. During the hot season fully-developed larvae were frequently found, whereas during our cool months the larvae hardly ever developed beyond the early stages, and, as a rule, only blood forms with the broadened posterior end were discovered. However, in addition to temperature, other factors which could not be determined seemed to influence the development.

On several occasions fleas collected from one dog were heavily infected, whereas fleas collected from another dog living in the same surroundings, with approximately the same number of parasites in the peripheral blood, showed only scanty parasites. Even fleas collected from the same dog showed great variation in the infection. The fleas of the same animal would show during one week a large number of forms in all stages, whereas the following week only blood, and perhaps early forms, could be found in the dissections.

In our experience, development of the filarial larvae occurred most often in the female flea; whereas in the male flea, only now and again were early developmental stages discovered.

The mode of transmission was considered, and it was thought possible that under normal conditions the flea would be crushed, and the actively motile larvae thus freed would penetrate through the unbroken skin and reach the blood stream in analogy with the mechanism of *Agchylostoma* infection.

In order to ascertain the correctness of the surmise, fleas were crushed over the shaved skin of young puppies which had been moistened with saline, and after an interval of from five to twenty minutes the part of the skin was excised and serial sections prepared for microscopical examination.

In one instance only out of seven experiments one mature larva was discovered in three consecutive serial sections with the anterior part (about 30μ of the larva) embedded in the subcutaneous tissue, the remaining part adhering to the outer skin. The larva had, without doubt, penetrated through the unbroken skin.

SUMMARY

The experiments carried out have proved that the larvae of *Dirofilaria immitis* can undergo a complete developmental cycle in the dog fleas, *Ctenocephalus felis* and *canis*. A mature larva on one occasion was found to have penetrated the unbroken skin of a puppy, making its way into the subcutaneous tissue.

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1908	Dansey-Browning, George
1908	Davidson, James
1908	Dickson, John Rhodes
1908	Dowdall, Arthur Melville
1908	Glover, Henry Joseph
1908	Greaves, Francis Wood
1908	Goodbody, Cecil Maurice
1908	Harrison, James Herbert Hugh
1908	Joshi, Lemuel Lucas
1908	Le Fanu, Cecil Vivian
1908	Luethgen, Carl Wilhelm Ludwig
1908	Mama, Jamshed Byramji
1908	McCay, Frederick William
1908	McLellan, Samuel Wilson
1908	Pearce, Charles Ross
1908	Schoorel, Alexander Frederik
1908	Smith, John Macgregor
1908	Stewart, George Edward
1908	Tate, Gerald William
1908	Whyte, Robert
1909	Abercrombie, Rudolph George
1909	Allin, John Richard Percy
1909	Armstrong, Edward Randolph
1909	Barrow, Harold Percy Waller
1909	Beatty, Guy
1909	Carr-White, Percy
1909	Chevallier, Claude Lionel
1909	Clark, William Scott
1909	Cope, Ricardo
1909	Fleming, William
1909	Hanschell, Hother McCormick
1909	Hayward, William Davey
1909	Henry, Sydney Alexander
1909	Innes, Francis Alexander
1909	Jackson, Arthur Frame
1909	Kaka, Sorabji Manekji

Date of Diploma	
1909	McCabe-Dallas, Alfred Alexander Donald
1909	Meldrum, William Percy
1909	Murphy, John Cullinan
1909	Samuel, Mysore Gnananandaraju
1909	Shroff, Kawasjee Byramjee
1909	Thornely, Michael Harris
1909	Turkhud, Violet Ackroyd
1909	Webb, William Spinks
1909	Yen, Fu-Chun
1910	Brabazon, Edward
1910	Castellino, Louis
1910	Caulcrick, James Akilade
1910	Dowden, Richard
1910	Haigh, William Edwin
1910	Hamilton, Henry Fleming
1910	Hefferman, William St. Michael
1910	Hipwell, Abraham
1910	Homer, Jonathan
1910	Houston, William Mitchell
1910	James, William Robert Wallace
1910	Johnstone, David Patrick
1910	Korke, Vishnu Tatyaji
1910	Macdonald, Angus Graham
1910	Macfie, John Wm. Scott
1910	Manuk, Mack Walter
1910	Murison, Cecil Charles
1910	Nanavati, Kishavlal Balabhai
1910	Nauss, Ralph Welty
1910	Oakley ,Philip Douglas
1910	Pratt, Ishmael Charles
1910	Sabastian, Thiruchelvam
1910	Shaw, Hugh Thomas
1910	Sieger, Edward Louis
1910	Sousa, Pascal John de
1910	Souza, Antonio Bernardo de
1910	Waterhouse, John Howard
1910	White, Maurice Forbes
1911	Blacklock, Breadalbane
1911	Brown, Frederick Forrest
1911	Chand, Diwan Jai
1911	Holmes, John Morgan
1911	Ievers, Charles Langley
1911	Iles, Charles Cochrane
1911	Ingram, Alexander
1911	Kirkwood, Thomas
1911	Knowles, Benjamin
1911	Liddle, George Marcus Berkeley
1911	Lomas, Emanuel Kenworthy
1911	Mackarell, William Wright
1911	MacKnight, Dundas Simpson
1911	Mascarenhas, Joseph Victor
1911	Murray, Ronald Roderick
1911	Oluwole, Akidiya Ladapo
1911	Rao, Koka Ahobala
1911	Sinton, John Alexander
1911	Tarapurvalla, Byramji Shavakshah
1911	Taylor, John Archibald
1911	Woods, William Medlicott
1912	Aeria, Joseph Reginald
1912	Anderson, Edmund Litchfield
1912	Borle, James
1912	Bowie, John Tait

Date of Diploma	
1912	Brassey, Laurence Percival
1912	Christie, David
1912	Dillon, Henry de Courcy
1912	Dunn, Lillie Eleanor
1912	Hardwicke, Charles
1912	Jagose, Jamshed Rustomji
1912	Kochhar, Mela Ram
1912	McGusty, Victor William Tighe
1912	Milne, Arthur James
1912	Mitra, Manmatha Nath
1912	Myles, Charles Duncan
1912	Pelly, Huntly Nevins
1912	Prasad, Bindeshwari
1912	Prentice, George
1912	Ross, Frank
1912	Russell, Alexander James Hutchison
1912	Ruthven, Morton Wood
1912	Sandilands, John
1912	Seddon, Harold
1912	Smalley, James
1912	Strickland, Percy Charles Hutchison
1912	Watson, William Russel
1913	Austin, Charles Miller
1913	Banker, Shiavux Sorabji
1913	Becker, Johann Gerhardus
1913	Carrasco, Milton
1913	Clark, James McKillican
1913	Forsyth, Charles
1913	Grahame, Malcolm Claude Russell
1913	Grieve, Kelburne King
1913	Hargreaves, Alfred Ridley
1913	Hepper, Evelyn Charles
1913	Hiranand, Pandit
1913	Jackson, Oswald Egbert
1913	Khaw, Ignatius Oo Kek
1913	MacKelvie, Maxwell
1913	MacKinnon, John MacPhail
1913	Macmillan, Robert James Alan
1913	Mouat-Biggs, Charles Edward Forbes
1913	Noronha, John Carmel
1913	O'Connor, Edward
1913	Olubomi-Beckley, Emanuel
1913	Pestonji, Ardeshir Behramshah
1913	Puttanna, Dodballapur Sivappa
1913	Reford, John Hope
1913	Smith, Edward Arthur
1913	Stewart, Samuel Dudley
1913	Walker, Frederick Dearden
1913	Wilbe, Ernest Edward
1913	Wilson, Hubert Francis
1913	Yin, Ulg Ba
1913	Young, William Alexander
1914	Arculli, Hassan el
1914	Chohan, Noormahomed Kasembha
1914	Connell, Harry Bertram
1914	Gerrard, Herbert Shaw
1914	Gimi, Hirji Dorabji
1914	Gwynne, Joseph Robert
1914	Hodkinson, Samuel Paterson
1914	Jackson, Arthur Ivan
1914	Kaushash, Ram Chander
1914	Kelsall, Charles
1914	Luanco y Cuenca, Maximino
1914	Misbah, Abdul-Ghani Naguib

Date of Diploma	
1914	Naidu, Bangalore Pasupulati Balakrishna
1914	Rowe, John Joseph Stephen
1914	Roy, Raghu Nath
1914	Shiveshwarkar, Ramchandra Vishnu
1914	Sur, Sachindra Nath
1914	Talati, Dadabhai Cursedji
1914	Wilkinson, Arthur Geden
1914	Wright, Ernest Jenner
1915	Lobo, John Francis
1915	Madhok, Gopal Dass
1915	Pearson, George Howorth
1915	Swami, Karumuri Virabhadra
1915	Wood, John
1916	Barseghian, Mesroob
1916	Chaliha, Lakshmi Prasad
1916	Lim, Albert Liat Juay
1916	Lim, Harold Liat Hin
1916	Metzger, George Nathaniel
1916	Söderström, Erik Daniel
1916	Wheeler, Louis
1917	Chapman, Herbert Owen
1917	Krishnamoorthy, Yedatore Venkoba
1917	Lipkin, Isaac Jacob
1918	Watts, Rattan Claud
1919	Bowle-Evans, Charles Harford
1919	Burnie, Robert McColl
1919	Celestin, Louis Abel
1919	Cummings, Eustace Henry Taylor
1919	Darling, Georgina Renington
1919	Drake, Joan Margaret Fraser
1919	Fraser, William James
1919	Gordon, Rupert Montgomery
1919	Krige, Christian Frederick
1919	Maplestone, Philip Alan
1919	Oluwole, Isaac Ladipo
1919	Rustomjee, Khusshuyee Jamesidjee
1919	Sawers, William Campbell
1919	Thompson, Mary Georgina
1919	Turner, Gladys Maude
1919	Young, Charles James
1920	Adler, Saul
1920	Anderson, William Jenkins Webb
1920	Campbell, George
1920	Cobb, Charles Eric
1920	Cobb, Enid Margaret Mary
1920	Fernandez, Daniel David
1920	Lim, Chong Eang
1920	McHutcheson, George Browne
1920	van der Merwe, Frederick
1920	O'Farrell, Patrick Theodore Joseph
1920	Renner, Edowo Awunor
1920	Vaughan, James Churchwill
1920	Waller, Harold William Leslie
1921	Nixon, Robert
1921	Richmond, Arthur Stanley
1921	Skinner, James Macgregor
1921	Stewart, Robert Bell
1921	Thomson, Marion

ANNALS OF TROPICAL MEDICINE AND PARASITOLOGY

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Articles for publication should not exceed twenty-five pages of the Annals, and will be understood to be offered alone to this Journal. They should be typewritten and addressed to:—The Editors, School of Tropical Medicine, The University, Liverpool.

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All lettering, names or legends on text-figures, charts or maps should be printed *sufficiently large* to allow of *clear legibility* on reduction if necessary.

Plates and illustrations should be accompanied by short explanations.

References to authors in the text must be made in the following way:—'According to Smith (1900) the spleen is enlarged, but Robinson (1914) says the reverse.' The references should be collected in alphabetical order of authors' surnames at the end of the paper, and arranged in the following way:—

ROBINSON, S. (1914). 'The spleen in malaria.' *Annals of Nosology*, Vol. XX, pp. 20-25.

SMITH, J. (1900). 'Enlargement of the spleen in malaria.' *Journal of Pathometry*, Vol. I, pp. 1-20.

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LIVERPOOL SCHOOL OF TROPICAL MEDICINE

SCIENTIFIC RECORD

COMPILED BY

DOROTHY ALLMAND

Librarian of the Liverpool School of Tropical Medicine

PLATES I—IX

The new laboratories of the Liverpool School of Tropical Medicine were formally opened on 24th July, 1920, by Lord Leverhulme, Honorary Vice-President and former Chairman of the School.

The building had been placed, in 1915, at the disposal of the Military authorities for the purposes of a hospital, and was used by them until 1919, for the treatment of patients suffering from tropical diseases, mainly malaria and dysentery. The hospital, which consisted of about 200 beds, was under the charge of Lieut.-Col. J. W. W. Stephens, R.A.M.C., Professor of Tropical Medicine, and during its four years' existence more than 3,000 cases were admitted.

Subsequent to evacuation by the Military authorities, the decoration and equipment of the laboratories were put in hand, and to-day the School affords excellent conditions and facilities for instruction and research.

The laboratories are situated in the University grounds, and close to the Royal Infirmary, in which the School has its Tropical Ward and adjoining clinical laboratory. In addition to the basement, which contains the Photographic Department and large storage rooms, there are four floors. The ground floor comprises the Lecture Theatre, with accommodation for about seventy students; the Library, where, besides text-books and miscellaneous scientific publications, over one hundred current medical journals from all parts of the world can be consulted; and the Museum, a spacious room, 80 feet by 69 feet, with preparation room adjoining.

E.K.P.
12-22-21

On the first floor are the Departments of Tropical Medicine and Entomology, the latter with its library of specialised literature, and six research rooms. The second floor comprises the excellently lighted class laboratory, 69 feet by 58 feet, and four research rooms devoted to the Department of Parasitology, while the third floor has a large research laboratory and two smaller research rooms. On the roof are an Insectarium, a mosquito-proofed house, and the animal houses.

The occasion of the official opening was marked by the issue of a volume* which traces the history of the School from its foundation down to the year 1920. The main purpose of this publication was to perpetuate the names of those who have been closely associated with the School in its varying activities in the past, and this aspect may here be briefly summarised before proceeding to an account of its scientific activities which, in the 'Historical Record,' are merely outlined.

The Liverpool School of Tropical Medicine was founded in 1898 by the late Sir Alfred Lewis Jones, K.C.M.G., a prominent Liverpool ship-owner, who, fired by an appeal for the study of tropical diseases issued by the late Rt. Hon. Joseph Chamberlain, then Secretary of State for the Colonies, offered to the President of the Royal Southern Hospital the sum of £350 for three years, to promote the special study of such diseases. Quarters were obtained in the Pathological Department at the University, and a Dean was appointed in the person of Professor Rubert Boyce, to whose tireless energy much of the early success of the School was due. In February, 1899, Dr. H. E. Annett was appointed Demonstrator in Tropical Pathology; in April, Major Ronald Ross accepted the post of Lecturer, and the School was officially opened; and in May teaching commenced.

The early history of the Liverpool School is a record of struggle; it was not founded by the Government, as was the London School; it had no grant, no assured income, nor even, at first, Government recognition. The School early turned its attention to research, and in the summer of 1899 the first of its expeditions was despatched to Sierra Leone. During the next fourteen years funds were

* Liverpool School of Tropical Medicine: Historical Record, 1898-1920. *At the University Press*, 1920. viii, 103 pp., 36 plates. 10/6 post free.

collected to equip and maintain more than thirty expeditions to various tropical regions, including West and Central Africa, Brazil and the West Indies.

In the meanwhile, at home the School was enlarging its scope and consolidating its position. In 1900 the Government gave it full recognition by placing it on the same terms as the London School with regard to newly-appointed medical officers and their courses of training, and four years later further recognition was received in the form of a financial grant from the Colonial Office, which grant was later increased and has continued to the present day. In 1901 a Lectureship and Fellowship were founded, in commemoration of the work of the late Walter Myers, who died of yellow fever in Brazil while serving with the Fourth Expedition. Major Ross was appointed to the former, and the latter was filled by Dr. J. E. Dutton, who, four years later, died in the Congo while investigating tick fever. In 1903 the Alfred Jones Chair of Tropical Medicine was founded, the first holder being Major Ross, while Dr. J. W. W. Stephens, who had joined the staff in the previous year, was appointed to the vacant Walter Myers Lectureship. In 1905 another important Lectureship was founded, namely, that of Economic Entomology, which was accepted by Mr. R. Newstead, of Chester. As the work and influence of the School increased, many new appointments were made, so that now, at the age of twenty-two, the School has three University Chairs,* namely, Tropical Medicine, Entomology and Parasitology, filled by Professors Stephens, Newstead and Yorke, respectively, assisted by a staff of eight Lecturers.

In 1903 the School moved into new laboratories, and in the following year a Diploma in Tropical Medicine was instituted.

In 1904 the Runcorn Research Laboratories were established for the purpose of conducting investigations on the large collection of trypanosomes and other protozoa, which had been amassed by members of the expeditions on various occasions. These laboratories were first placed in the charge of Dr. Wolferstan Thomas, and during their ten years' existence much valuable research was done there.

*** A fourth Chair, that of Tropical Diseases of Africa, has now (1921) been established, and is held by Professor B. Blacklock.**

In 1906 was issued the first number of the *Annals of Tropical Medicine and Parasitology.* This publication had been preceded by a series of twenty-one *Memoirs*, mostly reports of the School's expeditions.

In 1911 the Yellow Fever Bureau came into being with Dr. Harald Seidelin as Director. As the name implies, the Bureau was established for the purpose of promoting the study of the many problems surrounding this disease. A journal was issued, the *Yellow Fever Bulletin*, of which three volumes were published.

Clinical instruction to students of the School had formerly been given in a special ward at the Royal Southern Hospital. This hospital being at some distance from the laboratory, arrangements were subsequently made with the Royal Infirmary for the erection of a new tropical ward in the Infirmary grounds. The ward, which contains ten beds, with an adjoining clinical laboratory, was opened in 1914.

On the arrival of the Fifteenth (Yellow Fever) Expedition at Manáos in 1905, it was found necessary for the work of the Expedition to establish a laboratory of a more or less permanent character. The Manáos Research Laboratory remained in existence until January, 1909, when, owing to the return of its Director, Dr. Wolferstan Thomas, to Liverpool, it was closed. In June, 1910, Dr. Thomas returned to Manáos and opened the present laboratory. In 1914 it was decided to extend the activities of this branch of the School; the outbreak of war, however, caused all developments to be deferred until 1919, when three research assistants were appointed to the laboratory.

With a view to carrying on research work in tropical medicine, the School desired to establish a permanent laboratory on the West Coast of Africa. Funds were available, through the munificence of the late Sir Alfred Jones, and a suitable site on Tower Hill, Freetown, Sierra Leone, having been placed at the disposal of the School by the Colonial and War Offices, the laboratory is now in course of erection.

FIRST LABORATORY OF THE SCHOOL

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The following brief record of the research work of the School is dealt with under subjects; no attempt at a critical estimate has been made.

MALARIA AND SANITATION

The first Expedition left England in July, 1899, for Sierra Leone, and consisted of Major Ross, Dr. H. E. Annett, Dr. R. Fielding-Ould, Mr. E. E. Austen, officially appointed by the British Museum, and Dr. Van Neck, delegate of the Belgian Government to the School. The purpose of the Expedition was to study malaria in man, and a report of the work accomplished was published in 1902 as *Memoir* II. The investigators discovered two species of *Anopheles* in Freetown, namely, *A. funestus*, Giles, and *A. costalis*, Loew, and by dissection established the presence of blasts (sporozoites) in them. They concluded that both *A. costalis* and *A. funestus* are hospitable to the human Haemamoebidae; that *A. costalis* is hospitable to all three of the human species, and *A. funestus* certainly to *H. malariae*, and probably *H. vivax*; no observations were made regarding the connection of *A. funestus* with *H. praecox*. They further pointed out the difference between *Culex* and *Anopheles*, and studied more especially the bionomics of the latter. 'Precautions against the bites of gnats' and 'operations for reducing the number of *Anopheles*' were fully considered. Dr. Fielding-Ould continued the work of the Expedition at Freetown after the other members had returned to England, and he also prosecuted his researches at Accra and Lagos, his report of which is included in *Memoir* II. At Freetown six of twenty-nine *Anopheles* dissected showed parasites. Seventeen *Culex* gave negative results. At Accra fifty-two *Culex* were negative. At Lagos thirty-seven *Anopheles* were dissected and zygotes found in one. The reports dealt mostly with the sanitary survey of the districts.

In 1900 a third Malaria Expedition was sent to Northern and Southern Nigeria. This Expedition, which was composed of Drs. H. E. Annett, J. E. Dutton and J. H. Elliott, spent six months in Nigeria, and in *Memoirs* III and IV reports were published of the work done, the former relating to malaria and the latter to filariasis (see p. 37). Seven of two hundred and eighty-one *Anopheles*

dissected at Bonny were found to be infected with malaria; it was noted that it was difficult to decide what was the exact type of parasite present. The observation made by Koch and by the Royal Society's Commission that native children are infected with malarial parasites to a large degree was confirmed; the incidence of infection is given in the following table. It was also proved that

TABLE showing the total number of children examined and found infected throughout Nigeria.

Ages	Number examined	Number infected	Percentage infected
0-5	220	114	51·8
5-10	108	27	25·0
10+	40	4	10·0

quartan and simple tertian parasites exist in West Africa, a fact contrary to the experience of the Royal Society's Commission of the previous year. The bionomics of *Anopheles* were studied still further and a series of experiments in propagation carried out, confirming and elaborating the discovery of the previous Expedition that the female mosquito requires a meal of blood both for fertilisation and for the development of the ova. In their recommendations concerning prophylaxis they advocated (1) the segregation of Europeans at a distance of about half a mile (a principle already put forward by the Royal Society's Commission on Malaria also at work in West Africa), and (2) the surface drainage of areas around their quarters. In an appendix they gave charts and descriptions of cases of hyperpyrexial fever, first described by Thompstone and Bennett. The hyperpyrexial stage lasts one to three weeks, and is followed by very extended lysis. An exhaustive account was given in the second report (*Memoir* IV) of the mouth parts of the female *A. costalis*, and, in an appendix by Theobald twenty-five mosquitoes were described of which nine were new species, namely, *Stegomyia irritans*, *S. nigricephala*, *Culex duttoni*, *C. decens*, *C. pruina*, *C. invenustus*, *C. nebulosus*, *C. rima* and *C. invidiosus* (with figures).

In June, 1901, Major Ross and Dr. Logan Taylor went to Freetown to organise an anti-mosquito campaign. Work was

commenced by engaging the services of between thirty and forty men, who were divided into two gangs: the *Culex* gang and the *Anopheles* gang. The former collected from private houses all the broken bottles and buckets, empty tins, etc., in which *Stegomyia* and *Culex* breed; the latter drained the pools and puddles in which *Anopheles* breed in the streets and backyards of the houses. Reports on the progress of this campaign were published as *Memoir* V, Parts 1 and 2, and later Ross issued a small book: 'Mosquito Brigades, and how to organise them.'

In September, 1901, Dr. Dutton went to the Gambia and inspected the conditions of health there, with the result that the Colony organised measures similar to those in operation at Freetown (*Memoir* X). About 32 per cent. of the infections examined

TABLE showing the total number of children examined and found infected throughout the Gambia.

Ages	Number examined	Number infected	Percentage infected
0-5	78	64	82·0
5-10	22	20	91·0
10+	13	7	53·8

showed quartan parasites, and about a third of the malignant tertian cases showed crescents. The simple tertian parasite was found three times only.

Dutton noted the universal infection of canaries with *Halteridium*, which was also found in other birds.

Of twenty-four *A. funestus* dissected, one contained sporozoites and one zygotes.

A. costalis was found breeding in boats, street drains, wells, tubs and barrels, and in tidal water containing 1·7 per cent. salt, together with *C. thalassius*. It would appear that *A. funestus* and its varieties are rural mosquitoes, while *A. costalis* is essentially town bred and capable of utilising any small collection of water for breeding purposes.

In an appendix, descriptions of eighteen species were given by Theobald, including *A. costalis*, var. *melas*; *A. funestus*, var.

umbrosus; *A. funestus*, var. *subumbrosus*; *Stegomyia albocephala*, sp. n.; *Culex annulioris*, var. *gambiensis*, v. n.; *C. anarmostus*, sp. n.; *C. thalassius*, sp. n.; *C. euclastus*, sp. n.; *Lasioconops poicilipes*, gen. n., sp. n.; *Corethra ceratopogones*, sp. n. Eight specimens of *G. longipalpis* var. *tachinoides* were taken. Dutton recorded the finding of a filarial embryo in the thoracic muscle of *C. anarmostus*.

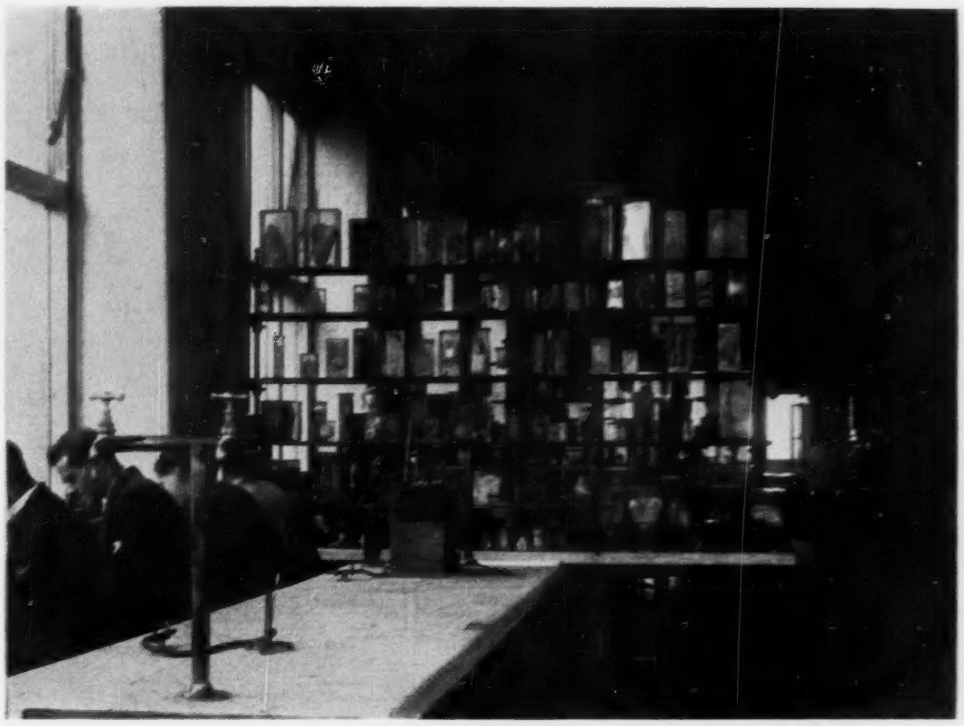
It was during his researches into the blood parasites of the Gambia that Dr. Dutton made a discovery of the highest scientific importance, namely, the identification for the first time of a trypanosome in the blood of a man, a patient of Dr. Forde. This parasite was subsequently (see p. 16) shown to be the cause of sleeping sickness, and was named ***Trypanosoma gambiense***, Dutton, 1902.

In 1901, Dr. C. Balfour Stewart was sent to the Gold Coast, to conduct operations similar to those carried on at Sierra Leone, while early in 1902 Major Ross again visited Freetown to ascertain by a thorough inspection the results of the previous Expedition. In the autumn of this year, Dr. Logan Taylor proceeded to Cape Coast Castle, Gold Coast, and reported upon the sanitary conditions prevailing there, with suggestions as to their improvement. (*Memoir* VIII).

In September, 1902, by request of the Suez Canal Company, Major Ross went to Ismailia to investigate the causes of the prevalence there of malaria, and to recommend measures for its prevention. *Anopheles* and *Culex* were found breeding in water containing 0·9 per cent. of salt. He concluded that the majority of *Anopheles* which caused malaria in Ismailia came from the marshes in immediate proximity to the town. Prophylactic measures based on his recommendations were commenced immediately (*Memoir* IX). In February, 1904, sixteen months later, Professor Boyce visited Ismailia; from statistics furnished in his report (*Memoir* XII), it appeared that the number of cases of malaria had fallen from 1,551 in 1902, to 209 in 1903.

During 1904, two Sanitary Expeditions were despatched to West Africa: one to Bathurst, Conakry and Freetown, and the other to the Gold Coast. Reports were published in 1905 as *Memoirs* XIV and XV.

In May, 1906, Professor Ross went to Greece in order to advise



SECOND LABORATORY OF THE SCHOOL

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the Lake Copais Co. with regard to anti-malaria measures. In the following year, at the request of the Colonial Office, he visited Mauritius for the same purpose; his report, entitled 'The Prevention of Malaria in Mauritius,' was published in 1908 (Waterlow & Sons).

In 1908, the Twenty-first Expedition of the School, consisting of Professor Newstead, Dr. W. T. Prout and Dr. Alan Hanley, was despatched to Jamaica. Reports were published in the *Annals of Tropical Medicine and Parasitology*, Vol. III, pp. 421 and 471, the first, dealing with medical and economic entomology, by Professor Newstead (see p. 39), the second, on malaria, by Dr. Prout. From data furnished by Dr. Neish, of Spanish Town, the frequency of the various species of malaria parasite was found to be approximately: simple tertian 54 per cent., malignant tertian 36 per cent., quartan about 1 per cent., and mixed infections about 8 per cent. The occurrence of several cases of blackwater fever was noted. The enlarged spleen rate in different parishes varied from 0 to 60 per cent. Prout found that the average percentage of malarial deaths to total deaths was nearly 20 per cent., that in four years the total admissions to hospitals from malaria had increased by 55 per cent., and that over 33 per cent. of the total admissions were due to malaria; it was reported that the annual cost of treating malarial patients was over £6,000. Various anti-malarial measures were recommended. In 1909, Boyce visited Jamaica, and reported upon the work done by the Commission appointed by the Governor in October, 1909, to deal with the malaria problem (*Annals*, Vol. IV, p. 233). It was recorded that one-half of the island, namely, those parts above 1,000 feet, was practically free from malaria-carrying mosquitoes.

Ross and D. Thomson, working in Liverpool, published a paper entitled 'Some Enumerative Studies on Malarial Fever' (*Proc. Roy. Soc.*, B., Vol. LXXXIII, p. 159, and *Annals*, Vol. IV, p. 267). Some of the conclusions were: (1) No fever exists unless the parasites exceed from 500 to 1,500 per c.mm.; (2) the parasites tend to remain continuously in the blood in small numbers between the febrile relapses; (3) close correlation between the number of parasites and the amount of fever caused by them; (4) studies on quinine gave a numerical estimate of its effect, a few days' use of the drug reducing the parasites by from 50 per cent. to 80 per cent.;

(5) crescents apparently require eight to ten days for development; quinine affects their numbers only by destroying the generating cells. Thomson, who subsequently investigated the life history of crescents (*Annals*, Vol. V, p. 57), concluded that these do not live for more than a few days in the peripheral blood. They are replenished from surviving asexual forms, and quinine has no action on crescents but only on the asexual source of supply. He concluded (*Annals*, Vol. VI. p. 223) that administration of quinine in doses of 20 grains daily for three weeks is almost certain to destroy both the asexual and sexual parasites. In a study of the leucocytes in malarial fever (*ibid.*, p. 83), he stated that malaria could be diagnosed by the leucocytic formula.

In 1912, J. G. Thomson and McLellan confirmed Bass's observations on the cultivation of malarial parasites. In twenty-four hours *P. falciparum* was found to undergo segmentation, the maximum number of merozoites counted being thirty (*Annals*, Vol. VI, p. 449). In the case of *P. vivax* (*Annals*, Vol. VII, p. 153), sixteen merozoites were produced. These cultures of *P. vivax* differed from those of *P. falciparum* in that there was no tendency to clumping. Further experiments in the cultivation of *P. falciparum* and *P. vivax* were made (*ibid.*, p. 509), when it was noted that the optimum temperature for cultures was 38° C.

Sinton, investigating Uriola's test of malarial pigment in the urine (*Annals*, Vol. VI, p. 376), concluded that it is almost impossible to exclude extraneous pigment.

In 1912, Dr. David Thomson was sent to Panama to study certain malarial problems with Dr. James, Chief Assistant Physician to the Ancon Hospital. The first part of his report (*Annals*, Vol. VII, p. 125) dealt with the sanitation in the Canal Zone, Trinidad and British Guiana; the second (*Annals*, Vol. VIII, p. 85) with the origin and development of gametes in malignant tertian malaria. He noted that they develop chiefly in the bone marrow and in the spleen, the period of incubation being about ten days.

While examining a malarial blood film sent from the Central Provinces of India, Stephens was struck by the peculiar appearance of the parasite (*Proc. Roy. Soc.*, B. Vol. LXXXVII, p. 375, and *Annals*, Vol. VIII, p. 119). It exhibited the following peculiarities:

(1) it was extremely amoeboid; (2) the cytoplasm was scanty; (3) the nuclear protoplasm was out of proportion to the volume of the parasite. It differed from *P. falciparum* by its amoeboid activity, and from *P. vivax* by its smaller size, the delicate nature of its amoeboid processes, the irregularity of its chromatin and the rarity of typical ring forms. Stephens proposed to name this parasite *P. tenue.* Later he described peculiar forms of a malaria parasite in a blood slide from the Gold Coast (*Annals*, Vol. IX, p. 169). In addition to these, large and apparently quite normal quartan parasites occurred, and it was possible to trace a transmission from normal ring forms to those in which chromatin particles or strands without any protoplasm were seen in the red cells.

In 1917, the School was asked by the War Office to undertake investigations into the treatment of malaria; the results of this work were published in thirty papers (*Annals*, Vols. XI-XIII).

No case was considered to be malaria unless parasites were found. The results of treatment were in all cases controlled by daily microscopical examinations combined with the clinical record.

Simple Tertian. The investigators established: (1) that intramuscular injection of quinine bihydrochloride was an effective method of treating a malarial attack, a matter which had been one of considerable dispute in the medical press just previous to this work. (2) That for the palliative treatment of malaria, that is, for keeping a person free from relapses over long periods, it was better to give a certain total amount of quinine on each of two consecutive days than on each of six days in the week: thus, 60 grains administered as 30 grains for two days gives a better result than the same amount administered as 10 grains for six days. (3) The best palliative result was obtained by administration of 45 grains on each of two consecutive days weekly over a period of two months. (4) They found that a certain treatment may give a certain 'curative'* result on one occasion, while the same treatment repeated on another occasion might give a quite different result. (5) Novarsenobillon was found to be as efficacious as quinine in the treatment of paroxysms, but its curative effect, like that of quinine, was practically nil. (6) The best 'curative' result was obtained by

* The term cure was used to signify no relapse within an observation period of 60 days after cessation of treatment.

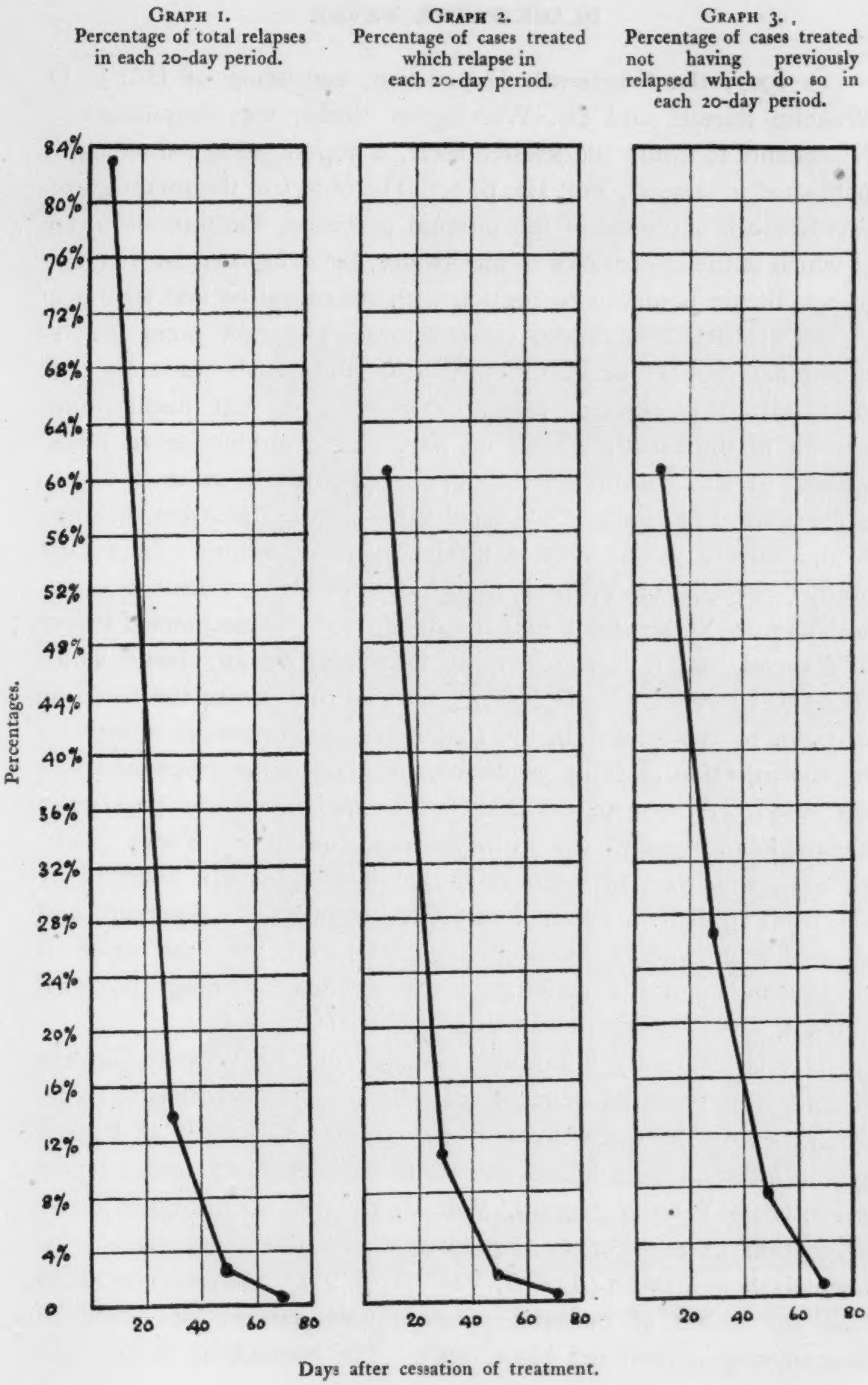
the administration of *Liquor arsenicalis*, minims 30, daily over a period of eight weeks in combination with two initial intramuscular injections of quinine bihydrochloride, grains 15, on two days only. Owing to the Armistice, these observations were not repeated.

The intravenous injection of quinine was found to have no real curative effect.

The relapse period after treatment of eight hundred simple tertian cases was recorded (*Annals*, Vol. XIII, p. 125). It is essential to recognise that these figures were based on an observation period of sixty days. The incidence is shown in the accompanying graphs. It will be seen that of those cases that relapse the majority do so in the first twenty days after cessation of treatment. Further, the time of occurrence of the paroxysms was noted in one thousand cases (*Annals*, Vol. XIV, p. 365). The majority occurred at 2 p.m. with the conditions of life under which the patients (soldiers) were living; over 90 per cent. occurred during the hours of activity, that is, between the hours of 7 a.m. and 6.59 p.m.

Malignant Tertian. Neither a single nor a series of six intravenous injections of quinine bihydrochloride (grains 10 to 15) caused the disappearance of parasites, either trophozoites or gametes, from the peripheral blood, whereas in the case of simple tertian the disappearance was rapid. Under quinine treatment, grains 30 to 45 daily, crescents did not persist in the peripheral blood in the majority of cases for more than three weeks. How long they persist without quinine was not determined.

In July, 1919, Blacklock and Carter recorded the experimental infection, for the first time, of *Anopheles plumbeus* with *P. vivax*. Experiments were made (*Annals*, Vol. XIII, pp. 187 and 413), with the result that the observers were able to obtain infections of the gut and salivary glands of laboratory-bred *A. plumbeus* at a temperature of 28° C.; at room temperature gut infection only was obtained. Infection of the gut was also produced with *P. vivax* in the case of *A. bifurcatus* at 28° C. Later experiments (*Annals*, Vol. XIV, p. 275) with *A. plumbeus* resulted in gut infection with oocysts of *P. falciparum* at 28° C.


Graph 1.
Percentage of total relapses in each 20-day period.
Graph 2.
Percentage of cases treated which relapse in each 20-day period.
Graph 3.
Percentage of cases treated not having previously relapsed which do so in each 20-day period.
84%
80%
76%
72%
68%
64%
60%
56%
52%
48%
44%
40%
36%
32%
28%
24%
20%
16%
12%
8%
4%
0
Percentages.
20
40
60
80
Days after cessation of treatment.

BLACKWATER FEVER

In 1907, the Nineteenth Expedition, consisting of Dr. J. O. Wakelin Barratt and Dr. Warrington Yorke, was despatched to Nyasaland to study blackwater fever, a report being subsequently published in *Annals*, Vol. III, p. 1. The object of the investigators was to trace out some of the internal processes, the terminal event of which is the appearance of blackwater, believing that in that way many obscure points in connection with the causation and treatment of the condition would be cleared up. The first point was to determine the action of quinine, acid and alkali upon the red cells during blackwater fever. They found that haemolysins, present in the blood, played no part in the production of blackwater. It was considered that the suppression of urine is due to a mechanical blocking of the renal tubes by the formation of large, firm, coarsely granular casts in the ducts of Bellini. In a later study (*Annals*, Vol. V, p. 287), on the suppression of urine in blackwater fever, Yorke and Nauss re-investigated the mechanical theory and found that it is considerably facilitated by any factor which tends to lower the blood-pressure, and by that means the secretion of water by the glomeruli, but that if the blood-pressure is kept up by the injection of saline solutions, the tendency to suppression is decreased. Arising out of these latter experiments, the passage of haemoglobin through the kidneys was studied by Yorke (*ibid.*, p. 401), who was led to consider that haemoglobin is excreted by the renal epithelium rather than filtered through the glomeruli, and that the amount of haemoglobin eliminated into the urine is dependent upon the activity of the epithelium lining the renal tubules.

It was shown by Simpson (*Annals*, Vol. VI, p. 313) that the haemoglobin liberated from the red cells in malaria escapes in larger quantities by the faeces than by the urine. The study of haemoglobin metabolism in blackwater fever was continued, and a report made (*Bio-Chemical Journal*, Vol. V, p. 378) on the quantitative estimation of urobilin in the excreta. In later observations on haemolysis in malaria (*Annals*, Vol. VI, p. 231), Simpson concluded that the serum of malarial patients may possess the power of haemolysing normal red blood cells. The haemolytic effect could

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not be obtained at all periods of the paroxysm, nor in every case; it appeared to be produced at the period of sporulation, and rapidly disappeared. Simpson and Edie (*ibid.*, p. 443), observing the excretion of urobilin in animals and man, found that an increase may occur after the administration of quinine in doses of 10 to 30 grains a day, and that a similar result follows injection of blood pigment or haemolytic drugs.

Experiments were devised by Barratt and Yorke (*Annals*, Vol. VIII, p. 509) for examining the relation of bile pigments to haemoglobin. Experimenting with rabbits, they found that consequent upon intravenous injection of haemoglobin solution there was a distinct and immediate increase not only in the concentration of the bile pigment, but also in the amount of bile pigment excreted. Two hypotheses were advanced to explain this increase: (1) that the haemoglobin injected is actually converted by the liver into bile pigment; or (2) that it merely stimulates the liver cells to an increased production of bile pigment.

Stephens (*Thompson-Yates Lab. Reports*, Vol. V, Pt. 1, p. 193) recorded that blackwater fever occurred in eleven of twenty-two of the United States. An account was given of the distribution of the disease, and an extensive bibliography appended. An analysis of ninety-five cases showed that when the blood was examined before the onset of blackwater, malarial parasites were present in 95·6 per cent. of cases, whereas on the following day the remarkable fall to 17·1 per cent. was the result. On the day of blackwater itself the figure was 61·9 per cent.

A series of studies in blackwater fever were made by Stephens (*Annals*, Vol. VII, p. 479). The subject was considered under the following headings: (1) malarial parasites; (2) pigmented leucocytes; (3) post-mortem examinations; (4) influence of malaria; (5) relationship to species of malaria parasites; (6) effect of period of residence; (7) seasonal prevalence; (8) correlation between malaria and blackwater statistics; (9) second attacks. A schedule for recording cases of blackwater was devised and recommended (*Annals*, Vol. VIII, p. 639). The results were recorded (*Annals*, Vol. IX, p. 201) of a statistical examination of the respective times at which quinine was given and blackwater occurred. Graphs were published showing that correlation existed between the time of

taking quinine and the onset of symptoms, but this did not necessarily imply any relationship of cause and effect. Data on the duration of haemoglobinuria were collected (*Annals*, Vol. IX, p. 539). In one hundred and sixty-seven records it was found that the duration was not more than twelve hours in a quarter of the cases, not more than one day in half the cases, and not more than two days in three-quarters of the cases. Finally, the importance of furnishing population statistics in connexion with cases of blackwater fever was emphasised (*Annals*, Vol. X, p. 345).

PIROPLASMOSIS

At Runcorn, Breinl and Hindle studied the morphology of *Piroplasma canis* (*Annals*, Vol. II, p. 233), and worked out the nuclear details of the parasite. Later, Breinl and Annett (*ibid.*, p. 383) concluded that the haemolysis in *Piroplasma canis* is not due to a formation of a specific haemolysisin or isolysin, but to the mechanical disintegration of the red blood corpuscles after the escape of the parasites from them. Barratt and Yorke found that in piroplasmosis the haemoglobinuria was attended with and dependent upon haemoglobinaemia. Of one hundred and forty-three cattle examined at Sierra Leone (*Annals*, Vol. IX, p. 418) about 5 per cent. were found to be infected with *P. bigeminum*, while *Theileria mutans* was encountered in between 20 and 30 per cent.

TRYPANOSOMIASIS

In view of the great importance of the discovery of the trypanosome in man by Dr. Dutton* in 1901, described and named by him *T. gambiense* (*Thompson-Yates Reports*, Vol. IV, p. 455), an Expedition was sent out to the Gambia and French Senegal in September, 1902, in charge of Dr. Dutton and Dr. J. L. Todd, for the study of Trypanosomiasis. While these investigators were at work abroad, the first case, that of a European who had returned with Dr. Dutton in 1901, remained in Liverpool, and Dr. Annett infected monkeys and 25 per cent. of tame rats successfully, but did not succeed in infecting tame mice, rabbits or guinea-pigs. One of the infected monkeys died, but the other recovered, and no parasites

* For the history of the discovery see Boyce, Ross and Sherrington, *Lancet*, Feb. 21, 1903.

could be found by sub-inoculation into rats. The results of his work were incorporated in the report of the Expedition (*Memoir* XI). On reaching the Gambia, one thousand and forty-three natives were examined, the majority of whom were children or young adults, and apparently healthy; six were found to be infected. Trypanosomes were also found in the blood of a quadroon. Clinical descriptions were furnished in the report of these first eight cases of trypanosomiasis, of which those of the European and the quadroon terminated fatally after a duration of about eighteen months. Of thirty-six horses examined, ten were found to be infected with trypanosomes. Transmission experiments were made with *Glossina palpalis* and later with *Stomoxys*, but with negative results. A series of inoculations were made of the human and equine trypanosomes in experimental animals, the results of which led Dutton and Todd to the conclusion that the parasites were not of the same species; the Gambian horse trypanosome was subsequently named *T. dimorphon*. Several new species of flagellates occurring in birds, mice, tortoises, etc., were described in this report, including *T. johnstoni*, *T. mega* and *T. karyzeukton*.

Prior to the return of this Expedition, the discovery of trypanosomes in the cerebro-spinal fluid of cases of sleeping sickness in Uganda by members of the Sleeping Sickness Commission of the Royal Society, caused the subject of trypanosomiasis to assume great importance. At the invitation of King Leopold, an Expedition was sent in 1903 to study sleeping sickness in the Congo Free State, consisting of Drs. Dutton, Todd and Christy. The results of these investigations were incorporated in *Memoir* XIII, and illustrated the occurrence and distribution of trypanosomiasis, described the symptoms of the disease in all its stages, both in Europeans and natives, and showed how sleeping sickness, so-called, is related to trypanosomiasis as a symptom of that disease.

They first stated that they were unable to find any difference between the trypanosome occurring in cases of sleeping sickness in the Congo and *T. gambiense*. There was a very evident clinical connection between cases with only very slight symptoms (trypanosoma fever) and advanced cases of 'sleeping sickness.' In twenty-five of thirty-eight cases they found parasites in the cerebro-spinal fluid, adopting Quincke's new method of diagnosis by lumbar

puncture. They infected rats, mice, rabbits, guinea-pigs, and studied the morphology of the Congo and Gambian trypanosome in these animals. They noted that about 50 per cent. of such inoculations failed, and that they did not succeed in infecting two dog-face monkeys (*Cynocephalus* species).

In the combined areas of Leopoldville, Boma, Matadi and the Cataract Region, among a total of 1,172 persons examined, 8·8 per cent. were infected, while of these latter 55 per cent. had been diagnosed as cases of sleeping sickness. In the Gambia, the previous Expedition had examined 1,043 natives, of which six only harboured trypanosomes, and showed no definite symptoms.

Numerous lumbar punctures were made, and it was noted that in many cases the trypanosomes never find their way into the cerebro-spinal fluid, and in those cases in which they do they are more likely to be found towards the termination of the disease; if they gain access early in the disease, mania and other cerebral symptoms are more likely to be prominent, but their entrance is in no way correlated to the commencement of the fever or other symptoms. In two later papers (*Memoir* XVI, p. 97, and *Memoir* XVIII, p. 1) on gland puncture in trypanosomiasis, the observers favourably compared this with other methods of demonstrating the presence of parasites. Following the work of Greig and Gray, they concluded that by gland puncture, cases infected with trypanosomes could be recognised at a much earlier period than hitherto. They also, for the first time, observed a phenomenon frequently seen in cases of trypanosomiasis, namely, auto-agglutination of the red cells. The distribution of sleeping sickness in the Congo was subsequently studied (*Memoir* XVIII), it being concluded that the increase during recent years was due, in a great measure, to the increase in travel following the opening up of the country. In a subsequent report (*Annals*, Vol. I, p. 233), the trypanosomiasis of cattle was dealt with. The investigators found that this disease was very widely distributed in the Congo, the infecting parasite being usually *T. dimorphon*. It was also observed that domestic animals probably acquire a relative immunity to some strains of trypanosomes, and may even recover spontaneously. Trypanosomes were found in horses, mules and donkeys as well as in cattle, and also in *Tragelaphus scriptus*.

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Thomas, assisted by Linton and Breinl (*Memoirs* XIII and XIV), established by a long series of experiments that trypanosomes found in (*a*) the cerebro-spinal fluid of Uganda sleeping sickness cases, (*b*) the cerebro-spinal fluid and blood of Congo sleeping sickness cases, (*c*) the blood of Congo 'trypanosome fever' cases, and (*d*) the blood of Europeans infected in the Congo, were identical in animal reactions and morphology with *T. gambiense*, Dutton. It was also found (1) that the periodicity of the parasite is a prominent feature, both in man and beast; (2) that the passing of a strain from a susceptible into a very resistant animal does not attenuate the organism, and that the morphological character is retained after being passed through many hundreds of animals for nearly three years; (3) that the parasites in an animal may sometimes become more virulent, that such a strain may be particularly virulent for one species of animal, and that the more rapid infection is not due to the inoculation of a greater number of parasites than usual. In addition to *T. gambiense* and *T. dimorphon*, other pathogenic trypanosomes were procured, and comparisons made between the above organisms and *T. evansi*, *T. brucei*, *T. equinum* and *T. equiperdum*. Cultivation of the different parasites was also undertaken with success. Breinl gave a detailed account of the post-mortem changes in four cases of sleeping sickness (*Memoir* XVI).

Extensive research was conducted into the treatment of trypanosomiasis, with the result that two drugs only were found to be of any value in the disease, namely, arsenic and 'Trypanroth'. Thomas introduced atoxyl, a meta-arsenic anilin compound, a drug which causes no pain on sub-cutaneous injection and may be administered over a period of many months. He stated that it was 'the only remedy at present giving a prospect of a cure.' Although atoxyl would almost invariably cause the trypanosomes to disappear from the peripheral blood yet since the parasites frequently reappeared, it seemed possible that they might exist somewhere else in the body of their host in a form uninfluenced by the drug. Series of experiments were, therefore, undertaken by Benjamin Moore and Nierenstein, of the Bio-Chemical Department, and Todd. They found that in the treatment of rats infected with *T. brucei* the administration of atoxyl, followed by bi-chloride of mercury, gave better results than treatment by atoxyl alone.

Moore, Nierenstein and Todd, continuing their researches on the treatment of experimental trypanosomiasis (*Annals*, Vol. II, p. 265), found that in small animals, such as rats and rabbits, infected with *T. brucei*, the results of treatment by atoxyl followed by mercury salts were far superior to treatment by atoxyl alone; in large animals, as donkeys, on the other hand, the combined treatment was not found to be efficacious enough to be of practical value. These workers also studied the effects of therapeutic agents on trypanosomes in respect to (*a*) acquired resistance of the parasites to the drug, and (*b*) changes in virulence of the strains after escape from the drug (*ibid.*, p. 221). Further bio-chemical research into the subject was made by Nierenstein, who observed the acidity and alkalinity of the blood in trypanosome infections, and found that whereas the total acidity of the blood serum showed a marked increase, the total alkalinity remained constant (*ibid.*, p. 227). Later he made an extensive study of the chemo-therapeutics of atoxyl (*ibid.*, pp. 249, 323 and 329). Breinl conducted some experiments on the combined atoxyl-mercury treatment of monkeys infected with *T. gambiense* (*ibid.*, p. 345), and demonstrated that in five cases out of six, the administration of acetylated atoxyl and sublimate, and Donovan's solution, to monkeys (*Cercopithecus callithricus*), effected a complete cure. As the result of Plimmer and Thomson's discovery of the trypanocidal action of antimony, Breinl and Nierenstein investigated the action of aryl-stibinic acids in experimental trypanosomasis (*ibid.*, p. 365), and showed that both *p.* and *m.* amino-phenyl-stibinic acids are fairly powerful trypanocides, the former being superior in its action. Owing to the satisfactory results obtained in laboratory animals, a trial of the former compound in sleeping sickness patients was advised, the dose suggested being the same as for atoxyl.

In May, 1907, the Eighteenth Expedition of the School, consisting of Dr. Allan Kinghorn and Mr. R. E. Montgomery, was despatched to Rhodesia and British Central Africa to study the trypanosomiases of men and animals (*Annals*, Vol. II, pp. 53, 97, 333 and 387; Vol. III, pp. 259, 277 and 311). It was found that sleeping sickness had already invaded N.E. Rhodesia, the first case being seen in the Luapula division, adjoining the frontier of the Congo. Glossina surveys were made, and the suggestion first

advanced that *Gl. palpalis* and *Gl. fusca* were not the only transmittors of the disease, *Gl. morsitans* having also been observed in infected areas. Gland palpations were made in 26,928 natives, of whom 17·05 per cent. were found to have palpable glands. The percentage of positive punctures was 77·7. The workers confirmed the belief of Dutton and Todd that gland palpation, combined with puncture, is a most useful measure, being a practical method of isolating infected natives, and preventing any rapid extension of the disease. It was found that there were between fifty and sixty known cases of sleeping sickness in the country. The mode of introduction and prophylaxis of the disease were studied, and regulations drawn up by this Expedition were adopted and enforced by the Government.

Concurrently with the research into human trypanosomiasis, the Expedition pursued an enquiry into trypanosomiasis of domestic stock in North-Western Rhodesia, in the course of which it was established that the disease was very prevalent in that area, and was due to *T. dimorphon*, *T. vivax* and a trypanosome morphologically allied to *T. brucei*. These trypanosomes could be transmitted by *Gl. morsitans*, by *Stomoxys calcitrans* and by a species of *Lyperosia*. The question of association of big game and *Gl. morsitans* was considered, the opinion being that the distribution of *Gl. morsitans* is entirely dependent upon the nature of the country and its flora, that the association with the fauna is largely fortuitous, and that a perpetual supply of mammalian blood is not imperative, at least to its temporary existence.

The classification of trypanosomes was attempted, the observers dividing the thirteen named species in the following way:—*T. theileri*, *T. equinum*, *T. gambiense* and *T. equiperdum*, easily recognised by their morphology or animal reactions; the nine remaining species sub-divided into three groups having as their types:—(1) *T. evansi* (with *T. brucei* and *T. sudanense*), (2) *T. dimorphon* (with *T. congolense* and *T. pecaudi*, and (3) *T. nanum* (with *T. vivax* and *T. cazalboui*).

Research was undertaken into many other points, and included observations on the parasites occurring in the intestine of *Gl. palpalis* and in the intestine and proboscis of *Gl. morsitans*.

The many problems of trypanosomiasis continued to occupy the

energies of the staff at Runcorn. Yorke took up the study of immunity in trypanosome diseases. He was able to prove (*Annals*, Vol. III, p. 565) that a diminution of the haemolytic complement only takes place in the last stages of the disease, and that, in an experimental case, the complement had practically vanished shortly before the death of the animal, when the blood was swarming with parasites. He also worked on the protective action of the serum of animals in a state of chronic infection or immune to various kinds of trypanosomes. Later, he investigated the condition of the blood which gives rise to the phenomenon of auto-agglutination of the red blood cells in animals infected with trypanosomes and to sleeping sickness in man (*Proc. Roy. Soc.*, Ser. B, Vol. LXXXIII, p. 238, and *Annals*, Vol. IV, p. 529). Experiments showed that auto-, iso- and hetero-agglutinin exist in the blood of many normal animals, and are frequently present in much greater amount in the blood of infected animals. Apart from infection with trypanosomes, well marked auto-agglutination was found to be an extremely rare phenomenon. Ross and Thomson studied a case of sleeping sickness and demonstrated a regular periodical increase of the parasites (*Annals*, Vol. IV, pp. 261 and 395). These workers confirmed the claim that there is a life cycle of trypanosomes in the vertebrate host (*ibid.*, p. 465). In 1910, Stephens observed a marked peculiarity in the morphology of a trypanosome from a rat supposed to be infected with *T. gambiense*. This parasite was described by himself and Fantham (*Annals*, Vol. IV, p. 343), the animal reactions observed by Yorke (*ibid.*, pp. 351 and 385), and a new species was founded, to which the name *T. rhodesiense* Stephens and Fantham was given, based on the peculiar posterior position of the macronucleus. It was later established that *T. brucei* exhibits this peculiarity.

In 1911, the Twenty-seventh Expedition of the School, consisting of Dr. J. L. Todd and Dr. S. B. Wolbach, was despatched to the Gambia to investigate sleeping sickness. Reports of the work done were published in the *Annals*, Vol. V, p. 245.

In the course of this investigation, 12,298 persons were palpated, and the observers put on record their opinion that gland palpation and puncture was by far the best procedure for the diagnosis of trypanosomiasis. It was found that at least 0·8 per cent. of the

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population of the Gambia was infected with trypanosomes. Strong recommendations were made for the control of the disease in the Gambia, including a continued examination of the whole population, the establishment of villages for isolation, observation and treatment of cases, and the appointment of a special staff for the administration and execution of these projects. Stannus and Yorke examined in rats the parasite from a case of sleeping sickness contracted in Nyasaland (*ibid.*, p. 443), and were convinced that the trypanosome in question was not *T. gambiense* but probably identical with *T. rhodesiense*, which it resembled very closely, having a posterior nuclear form. A study was made by Yorke and Blacklock of the trypanosomes from a horse naturally infected in the Gambia (*ibid.*, p. 413). The parasites consisted of a long form with a free flagellum, and also a short form without a free flagellum. The former was considered, from its morphological appearance and animal reactions, to belong to the *T. vivax* group; the latter form was subsequently identified (*Annals*, Vol. VI, p. 107) as *T. dimorphon*, sensu Laveran and Mesnil. Blacklock measured one thousand examples of this form, and found that the average length was 13·3μ (*Annals*, Vol. VI, p. 287). Measurements of one thousand examples of *T. vivax* in goats were made by Blacklock, the average length being 27·7μ (*Annals*, Vol. V, p. 521). He also, using the same strain of *T. vivax*, measured fifty trypanosomes drawn from a rat and a rabbit respectively. In the former the average length was 21·1μ, in the latter 20·8μ (*ibid.*, p. 537).

In 1911, at the request of the British South African Co., Dr. Kinghorn and Dr. Yorke were sent to Rhodesia (Luangwa Valley) to study sleeping sickness. It was quickly placed beyond doubt that *Gl. morsitans* was the carrier of the human trypanosome (*Annals*, Vol. VI, p. 1). The investigators inoculated rats from twelve cases of human trypanosomiasis, eleven of which occurred in villages in the Luangwa valley. In every instance they observed the posterior displacement of the macronucleus, characteristic of the trypanosome described by Stephens and Fantham; the animal reactions agreed in all respects with those obtained from infection with *T. rhodesiense*. Elaborate transmission experiments with both wild and laboratory-bred *Glossina morsitans* were successfully carried out in rats and monkeys; the duration of the cycle in the

fly (approximately fourteen days) was found to be shorter than in experiments of previous investigators with *Gl. palpalis* and *Gl. morsitans*. It was observed that an infected fly retains the power of transmitting the disease during its life, and is infective at each meal, but that mechanical transmission does not occur if a period of twenty-four hours has elapsed since the infecting meal. Certain species of buck, viz., waterbuck, hartebeest, mpala and warthog, were found to be infected with the human trypanosome, as well as a native dog. Later (*Annals*, Vol. VI, p. 269), it was found that 16 per cent. of the local game were infected with *T. rhodesiense*, and it was established that the game and fly strains were identical with the human trypanosome. In all, six species of tryanosomes were found in game and domestic stock in the Luangwa Valley (*Annals*, Vol. VI, p. 301), namely, *T. rhodesiense* and *T. pecorum*, transmitted by *Gl. morsitans* and probably by insects other than tsetse-flies; *T. vivax* and *T. nanum*, probably transmitted by *Gl. morsitans;* and two others, one of which was possibly *T. montgomeri*. At least 37·5 per cent. of the buck were found to harbour pathogenic trypanosomes. In a later report (*ibid*, p. 317) a new trypanosome, *T. ignotum*, infective to monkeys and a rabbit, was described. The vertebrate host was not discovered. This trypanosome is now known as *T. simiae*, having been previously found in the same year by the Royal Society S.S. Commission. Still later (*Annals*, Vol. VII, p. 254), descriptions were given of *T. multiforme*, sp. n., and of *T. tragelaphi*, the latter closely resembling *T. ingens*. In the course of experiments in the development of *T. rhodesiense* in *Gl. morsitans* (*Annals*, Vol. VI, p. 405), it was observed that the cycle was influenced to a marked degree by the temperature to which the flies were subjected, high temperatures (75° to 85° F.) being favourable and low ones (60° to 70° F.) unfavourable to the development of the parasites. Parasites might persist in the fly at at incomplete stage of their development for at least sixty days under unfavourable climatic conditions. It was found (*Annals*, Vol. VI, p. 495) that in every fly capable of infecting animals with *T. rhodesiense* the salivary glands were invaded, also that on every occasion on which the salivary glands were infective the trypanosomes in the intestines were virulent. Invasion of the salivary glands was only observed

in the case of flies infected with *T. rhodesiense* and not in the case of any other trypanosomes met with in the Luangwa Valley or on the Congo-Zambesi watershed. It was calculated that approximately 3·5 per cent. of the flies might become permanently infected and capable of transmitting the virus (*Annals*, Vol. VII, p. 183). The chief reservoir of the human trypanosome was found to be the antelope. Stephens and Fantham (*Proc. Roy. Soc.*, B, Vol. LXXXV, p. 223, and *Annals*, Vol. VI, p. 131) made a bionomic study of *T. rhodesiense*. One thousand specimens were measured, and it was found that the average length was 23·6μ, as compared with *T. gambiense* 22·1μ, and *T. brucei* 23·2μ. The average length of *T. rhodesiense* in man and other species of animals was ascertained. Those in the rat were found to be the longest (24·5μ) and those in the rabbit the shortest (19·4μ). Of the three species *T. rhodesiense* was found to be richest in long and poorest in intermediate forms. Another series of measurements was undertaken (*Annals*, Vol. VII, p. 27), when each day, for the first ten days of infection, one hundred trypanosomes from the same rat were measured, the results being again compared with *T. gambiense*. It was found that the day of infection was of great importance, as there was a great variation in the percentage of 'stumpy' forms on different days, *e.g.*, 53 per cent. on the seventh day to 5 per cent. on the tenth day. The larger the sample of trypanosomes taken, the smaller the variation in the average length.

J. G. Thomson succeeded in cultivating *T. rhodesiense* by the use of a modification of the Novy-MacNeal-Nicolle medium. The changes taking place in the trypanosomes were described (*Annals*, Vol. VI, p. 103), and it was noted that when development was rapid two distinct types could be distinguished on the fourth day. In cultures which develope more slowly the trypanosomes disappeared about the third or fourth day, reappearing about the sixth, and on the eighth day spirillar forms were seen to be splitting off. Differentiation into the so-called 'male' and 'female' forms took place during the eighth, ninth and tenth days. Inoculation of animals from the cultures was unsuccessful. In a subsequent investigation with J. A. Sinton (*ibid.*, p. 331), Thomson successfully cultivated *T. gambiense* as well as *T. rhodesiense*, the former for a period of thirty-seven days, the latter for twenty-one

days only. The life history of these trypanosomes in culture tubes was similar to that occurring in the gut of the insect host. The cultures lost their infectivity after the third day, and it was suggested that probably their transference to a new medium or environment similar to that of the salivary glands of the tsetse fly might be required to permit the full history of the trypanosomes being completed. Blacklock observed the vitality and changes undergone by trypanosomes in the cadaver of the animal host (*ibid.*, p. 55). He found that *T. gambiense* and *T. rhodesiense* can remain infective in the blood of the dead animal for forty-eight hours. Blacklock also made a study of the posterior nuclear forms of *T. rhodesiense* in rats (*Annals*, Vol. VII, p. 101). He found that they first appeared in the blood from the sixth to the tenth day of the disease, in a count of a thousand trypanosomes, that they increased in numbers in the later stage of the disease, and that they increased relatively to other forms of trypanosomes. They showed definite powers of resistance to disintegration in the cadaver of the animal host. It was suggested that such forms might occur as a constant constituent of certain strains.

Stephens and Blacklock made a morphological study of *T. brucei* (the Zululand strain) and of the trypanosome of the same name from the Uganda ox (*Annals*, Vol. VII, p. 303). They asserted the non-identity of the two strains, and proposed for the latter the name *T. ugandae*. Blacklock and Yorke (*ibid.*, p. 603), studying the pathogenicity of *T. congolense* (Broden) and *T. nanum* (Laveran), came to the conclusion that they were the same parasite.

Yorke and Blacklock studied the characters of the more important mammalian trypanosomes (*Annals*, Vol. VIII, p. 1), and compiled a convenient table of the main differential points. The value of the cycle of the trypanosomes in their invertebrate hosts as an aid to differentiation of species was also put forward.

Todd re-examined the flagellate found by Dutton in 1902 in the blood of Gambia house mice, and came to the conclusion that it was *T. acomys* (*ibid.*, p. 469).

Yorke and Blacklock experimented with antimony trioxide in the treatment of experimental trypanosomiasis (*ibid.*, p. 55), controlling and extending some of the work of Kolle and others on the use of this drug. Various strains were used in the experiments.

LECTURE THEATRE

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It was found that small animals could withstand a relatively much larger quantity of the drug than large ones. Post-mortem evidence proved that the proportion absorbed during a period of six months was exceedingly small. A certain number of cures would seem to have resulted, as several animals remained negative without relapse for over two hundred days, and sub-inoculated animals were not infected. Most strains appeared very susceptible to the drug, but *T. gambiense* and *T. lewisi* proved refractory.

Seidelin tested the effect of salvarsan-copper on white rats infected with a strain of trypanosomes of the *T. brucei* group kept in guinea-pigs and rats in West Africa (*Annals*, Vol. IX, p. 197). The best results were obtained with the injection of a dose of 0·0064 gm.; in such a case the trypanosomes disappeared from the blood on the following day and remained absent for fifteen days, death occurring on the twenty-eighth day; in several other cases the life of the animals was prolonged for a few days more.

The Thirty-second Expedition of the School, consisting of Drs. Yorke and Blacklock, was despatched to Sierra Leone in 1914. Research was undertaken into the bionomics of *G. palpalis* in Sierra Leone, with special reference to its pupal habits (*Annals*, Vol. IX, p. 249). It was found that the breeding-grounds of *G. palpalis* are not so strictly limited to the immediate vicinity of water as had hitherto been believed. Mangrove swamps do not constitute a breeding-ground. The pupae do not hatch when subjected to daily flotation on sea water. The ground around the trunk of oil palms which have not been stripped of their lower petioles constitutes an excellent breeding-place for *G. palpalis*; they can breed in localities in which practically the only tree is the oil palm. A study of the food of *G. palpalis* in the Cape Lighthouse Peninsula, Sierra Leone (*ibid.*, p. 363), showed that about 8 per cent. of the wild *G. palpalis* in that district contained recognisable red blood cells—7 per cent. of mammalian origin and 1 per cent. nucleated red cells of unknown origin. Neither shed blood nor other fluid which is exposed (not covered by a membrane) can be imbibed by *G. palpalis*. Fluids such as solutions of sugar, sodium chloride, etc., protected by a membrane (*e.g.*, thin rubber sheeting), were taken up, but less quickly and readily than blood. It was thought that in nature *G. palpalis* may, under certain conditions, take up fluids other than

blood. The human trypanosome (*T. gambiense*) was discovered in an ox in Sierra Leone (*ibid.*, p. 383), thus demonstrating that domestic stock forms a reservoir for the virus of sleeping sickness. Among other animal parasites found in domestic stock in Sierra Leone (*ibid.*, p. 413), *T. congolense* and *T. vivax* were most commonly encountered. Trypanosomiasis of cattle was common. Of one hundred and forty-three examined, trypanosomes were found in nineteen after a single examination.

In 1919, Escomel recorded the discovery of trypanosomes in the blood of a patient coming from Peru, which he described and considered to be *Schizotrypanum cruzi.* Yorke, examining this description, was led to doubt, on morphological grounds, whether the identification was correct, and proposed for this Peruvian parasite the name *T. escomeli*, in recognition of its discoverer. A feature of the symptomatology of the case was the overpowering somnolence from which the patient suffered, a symptom not hitherto noted in Chagas' disease, although a striking feature of the African trypanosomiasis of man (*Annals*, Vol. XIII, p. 459).

Macfie described a trypanosome found in the blood of a snake, *Naja nigricollis*, in the Gold Coast, resembling in some degree *T. primeti*, but differing from it in size and proportion. He proposed for it the name *T. voltariae* (*Annals*, Vol. XIII, p. 23).

YELLOW FEVER

In 1900, the Fourth Expedition, consisting of Drs. H. E. Durham and Walter Myers, went to Brazil to study yellow fever. Dr. Myers died of the disease in January, 1901, while Dr. Durham, who also contracted it, recovered and published a report of the work of the Expedition (*Memoir* VII) in 1902.

The U.S. Yellow Fever Commission in Cuba had not yet established the transmission by *Stegomyia* when the Liverpool Expedition set to work at Pará; for which reason the course of their investigation was chiefly directed at first to the search for some protozoal parasite. Only seventeen autopsies on yellow fever cadavers were obtainable. An extremely slender filiform bacillus was observed to occur constantly in the tissues and intestines, and much time was spent in isolating it and in attempts at cultivation.

Dissection of specimens of *Culex fatigans* captured in suspected houses showed large numbers of a similar bacillus. Owing to the death of Dr. Myers, the research came to an end.

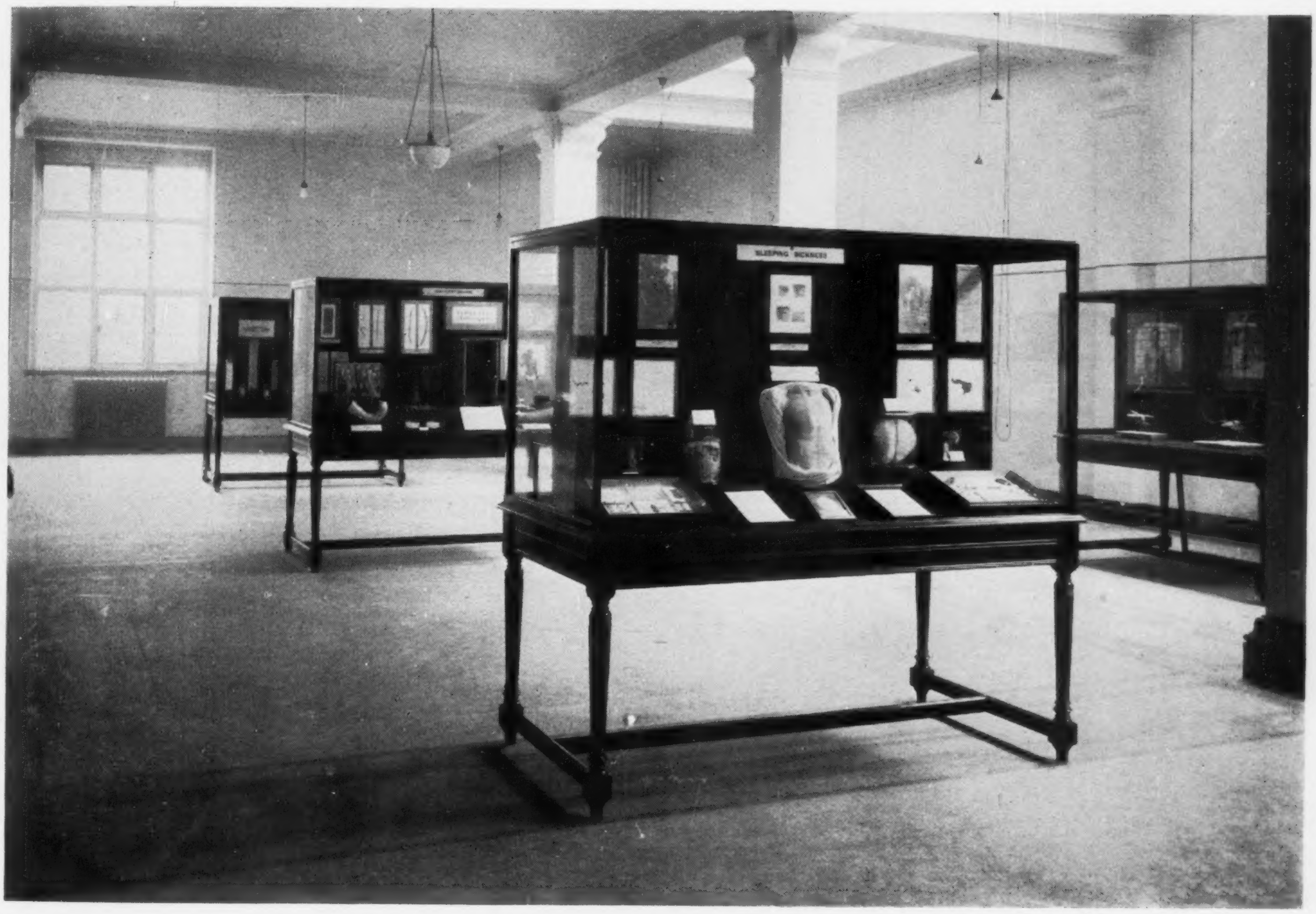
In 1905, Professor Rubert Boyce was despatched by the School to New Orleans, to observe the work of the U.S. Medical Authorities in dealing with the outbreak of yellow fever there. In *Memoir* XIX Boyce gave an account of the vigorous campaign which was successful in ridding the city of *Stegomyia*. Subsequently, at the request of the Colonial Office he visited Honduras to make a report on the conditions existing in that Colony with reference to a recent outbreak of yellow fever (Waterlow & Sons, 1906).

In April, 1905, a second Yellow Fever Expedition was sent to the Amazon, the members being Dr. Wolferstan Thomas and Dr. Breinl. A permanent laboratory was established so that patients could be kept under continued observation, and experiments inaugurated which would have been impossible under other conditions. Series of reports by Thomas were published in the *Annals*, Vol. IV, p. 1. It was recorded that the most serious disease to which the foreign population was liable was yellow fever, and this disease was made the object of extensive investigation. 'Chimpanzees have been successfully inoculated; rabbits and guinea-pigs exhibited certain reactions when inoculated with infective blood from yellow fever cases or subjected to the bites of infected *S. calopus*.' (See also *Trans. Soc. Trop. Med. and Hyg.*, Vol. III, p. 59.) The resources of the laboratory in Manãos were placed at the disposal of the State, the doctors, the hospital and the poor of the city. Examinations of blood, agglutination reactions for typhoid and paratyphoid, bacteriological examinations of water and milk, post-mortems and pathological reports were made, and the laboratory so conducted as to be of the greatest possible service to the community. Papers on 'Oesophagostomiasis in Man' and the condition known as 'Mossy Foot' were published in the *Annals*, as also an article on the 'Mosquitoes of the Amazon region' by Newstead jointly with Thomas.

In 1910, at the request of the Colonial Office, Professor Boyce was despatched to the Gold Coast and Sierra Leone, to report on the outbreak of yellow fever at those places (*Trans. Soc. Trop. Med. and Hyg.*, Vol. IV, p. 33). It was observed that the so-called

classical type of yellow fever was comparatively rare amongst native races, and the reason was advanced that natives are partially immunised by being born and brought up in an endemic area (*Annals*, Vol. V, p. 103). Those removed in childhood from such an area become non-immune, and therefore liable to succumb to an epidemic.

In 1911, the study of yellow fever was taken up with energy by Professor Boyce, who suggested and superintended the establishment of a Yellow Fever Bureau at the Liverpool laboratories. A *Bulletin* was issued, in which the Director of the Bureau, Dr. Harald Seidelin, and other investigators published the results of their researches. Abstracts of reports from all over the world were also made, and reviews published of current literature on yellow fever and allied subjects, including pappataci fever and dengue. Research was undertaken into the etiology, diagnosis and treatment of yellow fever. Seidelin observed the occurrence of protozoon-like bodies in the blood and organs of yellow fever patients (*Journ. Path. and Bact.*, Vol. XV, p. 282). At a meeting of the Society of Tropical Medicine and Hygiene, in January, 1911, these organisms were demonstrated in preparations of the blood and sections of the kidney, and later (*Yellow Fever Bulletin*, Vol. I, p. 229), Seidelin described their morphology, and proposed for them the name of *Paraplasma flavigenum*, g. n., sp. n. In December, 1911, he was despatched to Yucatan, where an epidemic of yellow fever was raging; a report of this Expedition was published in *Yellow Fever Bull.*, Vol. II., p. 123. The total number of cases officially diagnosed during the outbreak was seventy-three, with thirty-eight deaths. The existence of a 'microbe carrier' was put forward as being responsible for the maintenance of the virus during periods when the disease is latent, it being suggested that the fragile infected *Stegomyia* could not be the lasting reservoir. It was also considered that one attack does not necessarily confer immunity. The usually mild form of the disease in natives was said to be due either to an unrecognised infection in childhood or to the hereditary transmission of anti-bodies from immune parents. Clinical features of the cases observed were given. *Paraplasma flavigenum* was seen in fifteen confirmed cases of yellow fever out of sixteen examined. Summing up the results of his blood examinations for *P. flavigenum*



MUSEUM

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in undoubted cases of yellow fever, Seidelin found that on this and former occasions he had approximately one hundred and six positive cases out of a total of one hundred and twenty. Records were made of the examination of four hundred and twenty-one specimens as controls. In one hundred and thirty-six cases malarial parasites were found, and in two hundred and eighty-three no parasites at all, while in two young children under no suspicion of yellow fever *P. flavigenum* occurred. It was suggested that these, together with two others previously observed, might be 'microbe carriers.' Blood from yellow fever cases was inoculated into four guinea-pigs, but none showed symptoms resembling the disease. A mosquito survey of Merida was made, and recommendations advanced as to methods of extermination. A section of Seidelin's report was devoted to a reply to those who had criticised his work.

In 1915, the Yellow Fever Commission (West Africa) concluded that no proof had been given that *P. flavigenum* was of a protozoal nature, and that the nature of the virus of yellow fever still remained undetermined.

In December, 1912, Seidelin was sent to Jamaica in order to investigate the nature of the disease called 'vomiting sickness,' prevalent in that island during the winter months, and responsible for a considerable mortality, chiefly among native children. A report of this Expedition was published in the *Annals* (Vol. VII, p. 377) and also in the *Yellow Fever Bulletin* (Vol. III, p. 7). Sixty-two cases were observed, but no causal organism was recognised; it was concluded that 'vomiting sickness' was a local disease and could not be accepted as a form of meningitis, which view had been advanced by Scott two years before the latter's demonstration of its true origin.

RELAPSING FEVER AND SPIROCHAETES

By the death of Dr. Dutton from tick fever while serving with the Congo Expedition, the School suffered the loss of one of its most brilliant workers, who, although only twenty-nine years of age, had already won a recognised position throughout the scientific world. Towards the end of 1904, Dr. Dutton and Dr. Todd had reached Stanley Falls, and they were able to demonstrate independently the

cause of tick fever in man, a discovery made a few weeks previously by Ross and Milne in Uganda. Further, they were able to prove the transference of the disease from man to monkeys by means of a particular species of tick. In Todd's report of this discovery (*Memoir* XVIII) clinical descriptions were given of twelve native and two European cases (the last two being those of the investigators themselves), all of whom were infected with a spirochaete thought at first to be *S. obermeieri.* A number of inoculation experiments with laboratory animals were carried out, it being found that to monkeys alone the parasite appeared to be uniformly pathogenic. Observations were made upon the distribution and bionomics of the human tick in the Congo, and included in the report was a description of *Ornithodoros moubata* by Professor Newstead.

Research was proceeding at Runcorn upon material brought back from the Congo by Dr. Todd. Dr. Breinl, invalided home from the Fifteenth Expedition, carried out with Dr. A. Kinghorn extensive studies on 'tick fever' and 'relapsing fever.' Observations were made on the animal reactions of the spirochaete discovered in the Congo cases of human tick fever, and brought to England in infected monkeys and ticks. In the course of these experiments, infection was produced not only in monkeys, but also in a horse, a dog, rabbits, guinea-pigs, rats and mice. This fact caused the observers to conclude that the organism was distinct from *Spirochaeta obermeieri*, pathogenic hitherto to monkeys only. Further experiments were undertaken, confirming this conclusion; and the new species was given the name of *Spirochaeta duttoni* (Breinl and Kinghorn, 1906, *Memoir* XX). Studies were made of this organism (*Memoir* XXI), in the course of which a clinical comparison was made between African tick fever and European relapsing fever, and the research into the animal reactions of this spirochaete in various animals amplified and completed. Experiments in immunity were continued, the conclusions reached being: (1) In animals which have recovered from the infection there is a relatively active immunity of comparatively long duration; (2) immune serum cannot produce passive immunity, nor has it any curative action; (3) hyper-immune serum does not protect a susceptible animal, nor does it prevent relapse, but it mitigates the severity of the infection and occasionally cuts short an attack; (4) there is a slight inborn immunity of short

duration. It was also shown that *S. duttoni* may pass *in utero* from mother to foetus, and extensive studies were carried out to determine the rôle played by the spleen in infection by spirochaetes. Attempts were made to transmit spirochaetes by the bites of *Cimex lectularius*, but without success. Subsequently (*Annals*, Vol. I, p. 435) Breinl studied the morphology and life history of *S. duttoni*, while Markham Carter (*ibid.*, p. 15) described the multiplication and important changes in form of *S. duttoni* in eggs laid by infected ticks. Still later (*Annals*, Vol. V, p. 479), Fantham studied the life cycle of spirochaetes, amongst those considered being *S. duttoni*, *S. recurrentis* and *S. marchouxi*. Subsequently (*Annals*, Vol. VIII, p. 471) he investigated the granule phase of the parasite, a detailed study being given, while serving with the Expedition to Khartoum, to *S. bronchialis*, in which it was found that the granules formed by the spirochaete were the cross infective stages of the organism (*Annals*, Vol. IX, p. 391).

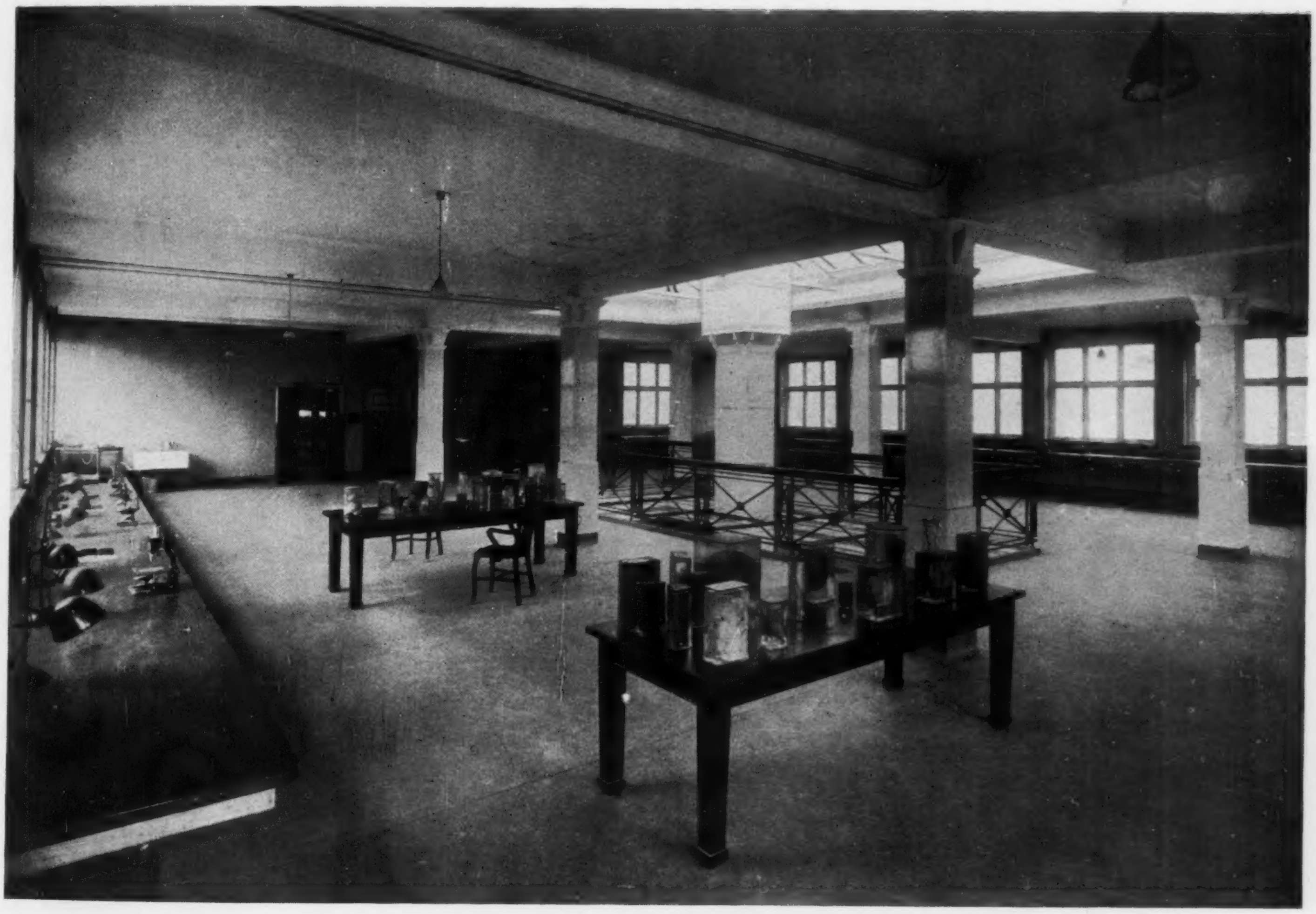
In 1917, while making microscopical examinations of stained smears from the stools of five hundred and fifty-four patients, admitted to hospital for dysentery, Carter found that 56·5 per cent. were infected with *Spirochaeta eurygyrata*. A control investigation on one hundred cases free from intestinal disorders showed 41 per cent. to be infected (*Annals*, Vol. X, p. 391). Repeating this investigation amongst a normal population, Macfie and Carter (*Annals*, Vol. XI, p. 75) examined eighty-two hospital patients suffering from some surgical condition, and twenty-three normal healthy men. None of the cases had ever resided in the tropics. Of the hospital patients 56·2 per cent., and of the healthy men 43·8 per cent., harboured *S. eurygyrata*. A second species of spirochaete was discovered in the intestine of one case, which, owing to its larger size and certain morphological peculiarities, was considered to be a new species, and named by them *Spirochaeta intestinalis*. Macfie and Yorke examined the morphology of the spirochaetes responsible for European, African and Indian relapsing fevers (*Annals*, Vol. XI, p. 81), and reached the conclusion that there is at present no means of distinguishing these parasites morphologically.

AMOEBIASIS

Research into the amoebae parasitic in the human intestine was undertaken by Fantham, and a study commenced of the life history of *E. coli* as seen in cultures (*Annals*, Vol. V, p. 111).

Carter, Mackinnon, Matthews and Smith conducted extensive researches into the protozoal findings in cases of amoebic dysentery. In their first report (*Annals*, Vol. X, p. 411) they recorded the results of four thousand three hundred and thirty-four examinations of nine hundred and ten patients suffering from this condition. Protozoal infections were discovered in 44·2 per cent.; *E. histolytica* was found in 10·3 per cent. of the cases; *E. coli* in 25·4 per cent.; *G. intestinalis* in 18·6 per cent.; *T. intestinalis* in 1·2 per cent.; and *C. mesnili* in 2·7 per cent. Their second report (*Annals*, Vol. XI, p. 27) recorded similar examinations of one thousand seven hundred and thirteen cases of dysentery. Stress was laid upon the necessity for repeated examinations of each patient, as cases found negative the first and second times may prove on further examination to be *E. histolytica* carriers. The subject of 'negative periods' (absence of vegetative forms and cysts) in infected cases was also dealt with. A third report of this investigation appeared in *Annals*, Vol. XIII, p. 83. Yorke and the above-mentioned observers examined for intestinal protozoa three hundred and forty-four persons who had never been out of England (*Annals*, Vol. XI, p. 87). Of this number, two hundred and six were healthy young men of about 18 years of age who had recently entered the Army. A single examination of each of these cases revealed the interesting fact that 3·9 per cent. were infected with *E. histolytica*. In an address to the British Medical Association (*B.M.J.*, April 12th, 1919), Yorke emphasized the importance of discovering whether the infection in this country is recent or otherwise. He was inclined to believe that it was not recent because (1) carriers must have frequently entered this country before the war; (2) all the necessary factors for the spread of the infection are to be found in this country; (3) there are authentic records of cases of amoebic dysentery and liver abscess before 1914.

Stephens and Mackinnon treated eighty-one cases infected with *E. histolytica* with 'alcresta ipecac,' an adsorption compound of



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emetine and aluminium silicate (*Annals*, Vol. X, p. 397), with the result that about two-thirds of the patients were freed from amoebic cysts. Carter and Matthews, using Cropper and Row's method of concentration (*Annals*, Vol. XI, p. 195), found *E. histolytica* cysts in five of one hundred and thirty-three apparently negative cases which had already received three ordinary routine microscopical examinations. Smith made a mensurative study of the cysts of *E. histolytica* and *E. coli* (*Annals*, Vol. XII, p. 27), and investigated the question of the number of races in the former parasite (*Annals*, Vol. XIII, p. 1). It was shown that not all infections of *E. histolytica* remain constant from one day to another in the average size of their cysts. The species can be divided into two races characterised by larger and smaller cysts, respectively. Infections with *E. histolytica* in healthy carriers who have never been out of England were shown to be characterised by a smaller proportion of the 'small' race, and also by a reduced proportion of the larger cysts of the 'ordinary' race, as compared with infections from convalescent dysenterics from abroad. Investigating the incidence of amoebic dysentery in asylum patients never out of England (*Annals*, Vol. XIII, p. 177), Smith found that of five hundred and four patients examined, fifty-nine had acute dysentery, and in three cases vegetative *E. histolytica* were found in the stools.

BERI-BERI

Simpson and Edie undertook research into the relation of the organic phosphorus content of various diets to diseases of nutrition, particularly beri-beri. After a review of the work of Schaumann and others (*Annals*, Vol. V, p. 313), the investigators recorded their own experiments with pigeons fed on various kinds of rice, white bread and whole-meal bread. A study was made of the anti-neuritic bases of vegetable origin in relationship to beri-beri, the properties of the yeast extracts investigated, and a method adopted for the isolation of torulin, the anti-neuritic base of yeast (*Annals*, Vol. VI, p. 235).

HELMINTHIASIS

Stephens (*Thompson-Yates Lab. Reports*, Vol. VII, p. 9), described the morphology of *Gastrodiscus hominis*, of two new human cestodes, *Dibothriocephalus parvus* and *Taenia bremneri*, of a new linguatulid, *Porocephalus pattoni* (*Annals*, Vol. I, p. 549), and of a new human nematode, *Strongylus gibsoni* (*Annals*, Vol. II, p. 315). Observations on the hooklets of *Cysticercus cellulosae* in man (*Annals*, Vol. II, p. 391) showed that there is an irregularity of development affecting both the number of the hooklets and, more especially, the size. A fluke, found by Newstead in the alimentary canal of a Nicaraguan turtle, was described by Stephens (*Annals*, Vol. V, p. 497), who proposed for it a new genus and named it *Desmogonius desmogonius*. The fluke from the liver of native dogs at Kasauli, India, was separated by Stephens from the genus *Opisthorchis* owing to the existence of a process or pedicle bearing on its summit the genital opening and a ventral sucker, and placed in a new genus as *Paropisthorchis caninus* (*Annals*, Vol. VI, p. 117). Breinl and Hindle described a new *Porocephalus*, found in the lung of one of their experimental monkeys, and distinguished from the known species by the presence of an appendage on the outer pair of hooks only. They proposed for it the name of *Porocephalus cercopitheci* (*Annals*, Vol. II, p. 321). Dogs in Freetown were found by Yorke and Blacklock to be heavily infected with *Ankylostoma caninum* and *A. ceylanicum*, the species being present in about equal numbers (*Annals*, Vol. IX, p. 425).

In 1916, Stephens contributed the section on Helminths to 'The Animal Parasites of Man,' issued jointly with Fantham and Theobald.

In 1917, at a Veterinary Hospital attached to a remount depôt in the neighbourhood of Liverpool, Yorke and Macfie started an investigation into the parasitic worms causing a heavy mortality amongst horses recently imported from America. The parasites belonged for the most part to various genera of the family *Strongylidae*, and in the course of their study Yorke and Macfie described eight new species and one new variety, viz., *Cylicostomum longibursatum*, *C. minutum*, *C. pseudocatinatum*, *C. pateratum*, *C. tridentatum*, *C. triramosum*, *Cylindropharynx rhodesiense*,

Gyalocephalus equi and *Cylicostomum nassatum*, Looss, var. *parvum* (*Annals*, Vols. XI-XIV).

Yorke and Southwell described a nematode from the intestine of a zebra, which certain minute characters of the head, and also the position of the vulva, led them to regard as a new species, for which they proposed the name *Crossocephalus zebrae* (*Annals*, Vol. XIV, p. 127).

FILARIASIS

The second part (*Memoir* IV) of the Report of the Third Malarial Expedition was devoted almost entirely to Filariasis. Eight new species, found during the examination of a large number of West Afrcan birds, were described, namely:—*F. cypseli*, *F. spiralis avium*, *F. fusiformis avium*, *F. spiralis avium major*, *F. falciformis*, *F. bibulbosa*, *F. capsulata* and *F. shekletoni*. Observations were also made on human filariasis in West Africa, it being found that throughout the whole of that area the natives appeared to be infected with *F. nocturna*, *diurna* and *perstans*. With regard to the two first species, the majority of the cases encountered were atypical, in that, embryos were either never absent from the peripheral blood, or the maximum did not occur at mid-day and mid-night or thereabouts according to the species. Among the former cases there were many showing decided periodicity, and, among the latter, the hour at which the maximum number was present varied considerably. In some cases, two maxima during the twenty-four hours were indicated. In the examination (day blood) of three hundred and ninety natives of all ages up to about eighteen years, one case only, aged eleven years, was infected. The observers succeeded in infecting *A. costalis* (proboscis) with *F. nocturna*. They considered that the weight of evidence was on the side of the identity of *F. nocturna* and *F. diurna*, but that many points remained to be cleared up before the question could be settled.

A study of the periodicity of *Microfilaria nocturna* was made by Yorke and Blacklock (*Annals*, Vol. XI, p. 127). They found that obstruction to the passage of *M. bancrofti* through the cutaneous vessels occurs at all times of the day and night, but is at a minimum

at the end of the period of bodily activity. Although this obstruction aids in the piling up of the larvae in the cutaneous vessels, it is in no way responsible for the nocturnal periodicity, which is primarily dependent upon periodic variations in the arterial supply of larvae to the cutaneous vessels. By reversing the hours of sleep and activity, cutaneous immigration gradually becomes diurnal instead of nocturnal, the complete inversion of the periodicity being accomplished in from four to eleven days. The number of microfilariae, as judged from the maximum concentration in the cutaneous blood, remained at practically a constant level during the period of observation. The number of microfilariae in the urine varied greatly, the variation giving no indication of either a nocturnal or a diurnal periodicity. The number of microfilariae in the renal and vesical vessels exhibited a nocturnal periodicity analagous to that in the cutaneous vessels.

ENTOMOLOGY

In 1907, Professor Newstead, jointly with Drs. Dutton and Todd, issued a report (*Annals*, Vol. I, p. 1) upon the insects and other arthropoda collected in the Congo Free State. Among the new genera and species described and figured were *Eretmapodites inornatus*, *Stegomyia luteocephala*, *S. albomarginata*, *Duttonia tarsalis*, *D. africana*, *Culex laurenti*, *C. par*, *Mimomyia africana*, *M. malfeyti*, *Boycia mimomyiaformis*, *Haematopota duttoni*, *H. trimaculata*, *Tabanus billingtoni*, *Glossina maculata* and *Stomoxys omega*. The habits and structural characters of the larva of *Simulium ornatum* (a European species) were described. They occur on the under sides of submerged leaves or blades of grass in those parts of a stream which are rapidly flowing and fully exposed to the sun. Their mode of progression resembles that of looper caterpillars, spinning a network of silken threads along which they travel. The period of pupation varies from two to six days. The imagines escape through a slit in the thorax, and occasionally may be seen completely immersed in water with their wings folded so as to encase an air bubble. The distribution of tsetse-flies in the Congo was recorded and illustrated by a map, together with observations on the bionomics of the flies. The life history of *Stomoxys calcitrans* was also described in detail.

ENTOMOLOGICAL DEPARTMENT

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In the following year, Newstead made a study of the bionomics of the common house-fly (*Annals*, Vol. I, p. 507). The chief breeding-places were determined, and it was established that the life-cycle of the fly, in all kinds of fermenting material, is reduced to the minimum period of ten to fourteen days; and that in the absence of such artificial heat the cycle may occupy a period from three to five weeks or more, according to the temperature of the outside air. It was found that house-flies do not depend entirely upon excessively warm weather for breeding purposes. Methods of prevention were suggested, and some notes appended on other insects found during the investigation.

In 1908, Newstead went to Jamaica to study cattle ticks. In the course of the investigation, twenty-five estates were visited and the cattle inspected in each, and large numbers of ticks were collected in every district (*Annals*, Vol. III, p. 421). Methods of treating tick-infected stock were made the subject of enquiry, and whenever possible practical demonstrations were given. The nature and extent of injury caused by insects and other pests to cultivated crops was studied, and methods of control advised. Descriptions were given of the nine species of ticks found in Jamaica, namely, *Argas persicus*, *Margaropus annulatus australis*, *Rhipicephalus bursa*, *R. sanguineus*, *Dermacentor nitens*, *Amblyomma maculatum*, *A. cajanense*, *A. dissimile*, *Aponomma* sp.

In 1906, Newstead investigated the life history of *Stomoxys calcitrans* (*Journ. Econ. Biol.*, Vol. I, p. 157) and, together with Stephens, described the anatomy of the proboscis of *Glossina palpalis* (*Memoir* XVIII, p. 53), and subsequently (*Annals*, Vol. I, p. 169) that of *Stomoxys calcitrans*.

In 1906, a former student, Capt. R. Markham Carter, I.M.S., forwarded to Newstead a species of tsetse-fly (namely, *G. tachinoides*) from Arabia, this being the first observation of the occurrence of *Glossina* outside Africa.

In 1910, Newstead described three new species of *Glossina* (*Annals*, Vol. IV, p. 369), namely, *G. submorsitans*, *G. brevipalpis* and *G. fuscipes*. These new species were founded on an examination of the morphological characters of the male genital armature. A revision of *Glossina*, based on a study of this structure, was made (*Bull. Ent. Res.*, Vol. II, p. 9), and later two further new

species of this genus were described, namely, *G. austeni* (*Annals*, Vol. VI, p. 129, and *Bull. Ent. Res.*, Vol. III, p. 355) and *G. severini* (*Annals*, Vol. VII, p. 331).

In 1911, as a member of the Commission of the Royal Society to enquire into the relation of the African fauna to human trypanosomiasis, Newstead proceeded to Nyasaland, and for five months devoted himself to a study of the bionomics of the tsetse-fly (*Glossina morsitans*, West.), with a view to discovering its breeding grounds and devising means of checking its spread. The results of this investigation were published, jointly with Dr. J. B. Davey, in the Reports of the Commission, No. XV, p. 142. The physical features of the country were first described and an account given of the vegetation of the river and its borders, and the forest or fly area. The vertebrate fauna of the district were then dealt with. It was concluded that mpala antelopes supplied a very large proportion of the food necessary for the life and propagation of *Glossina*. Two species of birds were shown to prey upon *G. morsitans*. The breeding grounds of *G. morsitans* were thinly scattered over the whole of the country, and large numbers did not occur in any given spot. It was found by experiment that the average time between each meal was about two and a half days. The period that elapsed between the date of capture of the fly and the production of the larvae varied from two to twenty-nine days. The duration of the pupal period was found to be about twenty-five days. The period of chief activity of *G. morsitans* was between the hours of 10 a.m. and 4 p.m.

In 1919, Miss A. M. Evans made a study of the genital armature of the female *Glossina* (*Annals*, Vol. XIII, p. 31). In 1918, Newstead discovered that the innumerable papillae which form the sculpturing on the exterior of the prominent lobes at the anal extremity of the larvae of *Glossina* are respiratory openings, and evidently function as such during the inter-uterine life of the larva. Similar structures were found in the *Hippoboscidae* (*Annals*, Vol. IV, p. 93).

Jointly with Carter, a new genus and three new species of anopheline mosquitoes were described (*Annals*, Vol. IV, p. 377), namely, *Dactylomyia*, nov. gen., and *Dactylomyia ceylonica*, *Pyretophorus cardamatisi* and *Cellia cincta*, and later

six further new species and varieties were dealt with (*Annals*, Vol. V, p. 233). In 1911, Newstead and Carter founded a new genus of Culicinae from the Amazon region, which they named *Thomasina*. The type species, *Thomasina longipalpis*, had previously been referred by Newstead and Thomas to the genus *Mansonia*, but it was now found that the morphological characters of the palpi and tarsi were so markedly different from those of *Mansonia* that the species could no longer remain in that genus (*Annals*, Vol. IV, p. 553). Some mosquitoes of the genera *Banksinella* and *Taeniorhynchus* were described by Carter (*Annals*, Vol. VII, p. 581) with a view to establishing the affinities of certain species and in reference also to the synonymy adopted by other students of this group of blood-sucking insects. In 1920, Carter gave an account of the male genital armature of the British anopheline mosquitoes (*Annals*, Vol. XIII, p. 453). Extensive observations were made by Blacklock and Carter on the bionomics of *A. plumbeus* (*Annals*, Vol. XIII, p. 421). It was found to be essentially a tree-hole breeder; larvae were taken from the water in rot-holes of elm, sycamore and other trees, from 2 to 20 feet above the ground. The breeding-places may occur in more or less isolated trees situated sometimes within a few yards of houses. *A. plumbeus* feeds on man both day and night. The observers obtained larvae from tree-holes in December to February, and they ascertained that thirty-five out of forty larvae survived freezing for five to thirty minutes. (For infection experiments with *A. plumbeus*, see p. 12).

In 1912, Carter described three new species of the genus *Tabanus*, which he named *Tabanus nagamiensis*, *T. fulvicapillus* and *T. donaldsoni*, and in a subsequent study (*Annals*, Vol. IX, p. 173) eight previously undescribed Tabanidae were dealt with. He also described three new African midges (*Annals*, Vol. X, p. 131), *Forcipomyia lefanui*, *Culicoides cordiformitarsis* and *Culicoides stephensi*, and later (*Annals*, Vol. XII, p. 289) two others, *Culicoides ocrothorax* and *Forcipomyia ingrami*, a species of interest owing to the fact that, given favourable opportunities for attack, its larvae prey upon the larvae of mosquitoes breeding in rot-holes in trees. In 1920, Carter, Ingram and Macfie commenced an exhaustive study of the Ceratopogonine midges of the Gold Coast, with descriptions of new species. In the first account of

these midges (*Annals*, Vol. XIV, p. 187), after a description of the technique employed, the observers dealt with the bionomics of the various genera. The second instalment (*ibid.*, p. 211), which began a systematic account of the Ceratopogoninae, dealt with the genus *Culicoides*, and included descriptions of sixteen species, eleven of which were new. The larvae and pupae of several species were described in detail. The third account of this investigation (*ibid.*, p. 309) dealt with six new species belonging to three genera, of which one of the latter is new.

In 1919, an article on the blood-sucking *Nematocera* was contributed by Carter to 'The Practice of Medicine in the Tropics' (now in the press). This dealt with the biting flies of the families *Culicidae*, *Psychodidae*, *Chironomidae* and *Simuliidae*. The account included general considerations regarding structure and bionomics, the species of malaria-carrying *Anopheles* being arranged in groups according to the nature of the evidence on which they were incriminated, and the classification. In the last section, the diagnostic characters of all the known (one hundred and twenty) Anopheline mosquitoes were given in synoptic tables.

Newstead continued his researches on *Coccidae*, of which the British species formed the subject of a monograph, in two volumes, issued by him among the Ray Society publications, in 1900 and 1902. In 1908, he contributed an article on these insects to the reports of the Swedish Zoological Expedition to Kilimandjaro (Vol. II, Part 12); the same year he wrote of the scale insects and mealy bugs of Egypt (*Liv. Univ. Inst. Comm. Res. in the Tropics Quart. Journ.*, Vol. III, p. 14), and reported upon a collection of Coccidae affecting plants in Java and West Africa (*Journ. Econ. Biol.*, Vol. III, p. 32). In 1910 and 1911, he described two new species of African coccids (*Journ. Econ. Biol.*, Vol. V, p. 18), reported on a collection from Uganda (*Bull. Ent. Res.*, Vol. 1, pp. 63 and 185), on another from South and South-west Africa, and on a third in the Berlin Zoological Museum (*Mitt. aus dem Zool. Mus. in Berl.*, Vol. V, p. 155). Later, he commenced a series of studies on Coccidae, which are still being pursued (*Bull. Ent. Res.*, 1913-1920). In these papers, over one hundred and sixty different species were dealt with, including the descriptions, with illustrations, of one hundred and six species and varieties new to science; the major portion of these are serious pests to various crops under

cultivation in tropical and sub-tropical countries. In 1910, Newstead served on the Special Commission appointed by the Government of Malta to suggest means for stamping out the fluted scale insect (*Icerya purchasi*), then threatening the orange-growing industry of the island. Regulations for the suppression of the pest were drafted and circulated.

Other work of an economic nature undertaken by Newstead included an investigation into the food of some British birds (*Suppl. to Journ. of Board of Agric.*, Vol. XV). This work, which had extended over a period of twenty years, was based upon over eleven hundred records, chiefly *post mortem*. His tentative verdict was in favour of the birds, the records showing what an important part is played by the majority of British birds in checking the increase and lessening the ravages of many insect pests of plants and crops. In 1910, Newstead dealt with some insects affecting cultivated plants in the West Indies (*Journ. Roy. Hort. Soc.*, Vol. XXXVI, p. 53), and in 1913, jointly with Bruce Cummings, issued a paper on a gall-producing Psyllid from Syria (*Ann. Mag. Nat. Hist.*, Vol. XI, p. 306).

In 1910, Newstead went to Malta to investigate sand flies of the genus *Phlebotomus*, the main object being to discover the chief breeding-places of these insects, and to recommend practical measures for destroying them in the larval stage. It was discovered that four distinct species of *Phlebotomus* occur in the island, previous investigators having notified one species only. The discovery of some important structural details concerning the anatomy of these insects was made and a long series of drawings illustrative of the salient characteristics was prepared, as well as a series illustrative of the internal anatomy (*Annals*, Vol. V, p. 139). Later, he described some new species (*Bull. Ent. Res.*, Vol. III, p. 361, Vol. V, p. 179, Vol. VII, p. 191, and Vol. XI, p. 305), and in 1913 dealt with three West African species (*Bull. Soc. Path. Exot.*, Vol. VI, p. 124).

Besides the special studies noted above, many articles on entomological subjects were contributed to a variety of journals by the Department of Entomology. In addition, innumerable collections of insects submitted by the Imperial Bureau of Entomology, by the Belgian Government, and from other sources, were examined and identified.

In 1915, Newstead went to France and Flanders, there to

organise measures of fly control. A report of this work was submitted to the War Office.

By the request of the Royal Society, Newstead and others commenced in 1916 an investigation into the problems connected with the damage caused to grain and flour during transit and in storage. It was found that wheat and flour are liable to attacks and injury by acarids, of which *Aleurobius farinae* was most commonly encountered. It was established that mites will not injure wheat and flour in which the moisture content is 11 per cent. or under, whatever the temperature may be. The morphology and bionomics of the infesting mites were studied, and experiments carried out with regard to methods of destruction. Newstead and Morris also reported upon the non-parasitic or forage acari of the family *Tyroglyphidae*, to which Pillers added clinical notes derived from veterinary experience (*Royal Society*: *Reports of the Grain Pests* (*War*) *Committee*, Nos. 2 and 8).

David Thomson made feeding experiments with the European bed bug (*Cimex lectularius*) in various diseases (*Annals*, Vol. VIII, p. 19). He found that protozoa were absent from the gut of this species (one hundred and eighty-four examined). No acid-fast bacilli were found in one hundred and five bed bugs fed on lepers, nor in thirty-five others caught in bed mattresses of leper patients. Nothing abnormal was found in bugs fed on cases of lymphadenoma, carcinoma and malaria. Forty bugs fed on a case of spleno-medullary leukaemia all developed numerous Charcot-Leyden crystals in their intestines.

Dutton, Todd and Christy described the Congo floor maggot, a blood-sucking dipterous larva found in the Congo Free State (*Memoir* XIII, p. 49). The larva was stated to be semi-translucent, of a dirty white colour, acephalous, amphipneustic, consisting of eleven segments, and to feed mainly, or entirely, at night. The duration of the pupal stage was a fortnight to three weeks. A light-brown fly, caught in many huts infested with the maggot, was subsequently identified by Austen as *Auchmeromyia luteola*. Newstead (*Annals*, Vol. I, p. 49) noted that the true larval stage is continued till after the formation of the puparium, and that a large percentage of the flies escape backwards from it.

In addition to dealing with the anatomy and bionomics of

Ornithodoros moubata, the tick transmitting African relapsing fever (already mentioned above), Newstead, jointly with Todd, described a species of acarid found infecting the lungs of monkeys, namely, *Pneumonyssus duttoni* (*Memoir* XVIII, p. 41), and later he described another new acarid, *Pneumonyssus griffithi*, found in the lungs of the Rhesus monkey (*ibid.*, p. 47).

PROTOZOOLOGY

Dutton, Todd and Tobey gave an account of certain parasitic protozoa observed by them in Africa (*Memoir* XXI, p. 87, and *Annals*, Vol. I, p. 285) in mammals, birds and reptiles, including full descriptions and figures of some forms of *Leucocytozoon ziemanni*, parasitic in a grey hawk of the Congo. Fantham studied the leucocytozoon, *L. lovati*, of the red grouse, *Lagopus scoticus*, and observed the occurrence of schizogony in its life cycle (*Annals*, Vol. IV, p. 255). He also studied a flagellate found in the alimentary tract of the body louse, which he named *Herpetomonas pediculi* (*Annals*, Vol. VI, p. 25), and of which he demonstrated the complete life cycle, notifying its occurrence in lice in England, as well as in India and Tunisia (*ibid.*, p. 403). Another Herpetomonas, *H. stratiomyia*, sp. n., was discovered by Fantham and Porter (*Annals*, Vol. VII, p. 609) parasitic on the larvae, pupae and imagines of the flies *Stratiomyia chameleon* and *S. potamida*. Research into induced herpetomoniasis in birds resulted in producing this condition in canaries, sparrows and martins by feeding them on insects containing herpetomonads; in some cases the infection was fatal. It was found that the cycle of the flagellate in the avian host resembled morphologically that in the insect (*Annals*, Vol. IX, p. 543). Fantham and Porter studied the effects on their hosts of certain *Myxosporidia* inhabiting the gall bladders of various fish (*Annals*, Vol. VI, p. 467). In 1916, Fantham contributed the section on the Protozoa to 'The Animal Parasites of Man,' issued jointly with Stephens and Theobald.

Seidelin described some blood parasites in reptiles (*Annals*, Vol. V, p. 371), and also some species of *Klossiella* in the kidney of a guinea-pig (*Annals*, Vol. VIII, p. 553). E. H. Ross observed the development of a leucocytozoon in a guinea-pig, for which he

proposed the name *Lymphocytozoon cobayae* (*Proc. Roy. Soc.*, B., Vol. LXXX, p. 67); Sinton prosecuted research into the morphology and biology of *Prowazekia urinaria* (*Annals*, Vol. VI, p. 245); and O'Farrell, in a study of hereditary infection, with special reference to its occurrence in *Hyalomma aegyptium* infected with *Crithidia hyalommae*, gave an account of the four periods in the life cycle of this flagellate (*Annals*, Vol. VII, p. 545).

In 1917, Smith and Matthews investigated the incidence of intestinal protozoa in two hundred and fifty patients admitted to hospital for diseases other than dysentery (*Annals*, Vol. X, p. 361). *Entamoeba histolytica* was found in 8 per cent. of the cases, *E. coli* in 19·2 per cent., *G. intestinalis* in 8 per cent., *C. mesnili* in 2 per cent., and *T. intestinalis* in 1·7 per cent. Of the two hundred and fifty cases examined, two hundred and two were suffering from non-intestinal complaints, and of this number 9·4 per cent. were found to be harbouring cysts of *E. histolytica*. Among ninety-one men who had been to France only, two were discovered to be 'carriers' of *E. histolytica*. In a further investigation (*Annals*, Vol. XI, p. 183), two hundred non-dysenteric patients were examined, and protozoal infections found in 34·5 per cent.; *E. histolytica* in 7·5 per cent. Matthews described and figured the characteristic morphological features of cysts of the common intestinal protozoa of man (*Annals*, Vol. XII, p. 17), and later made a mensurative study of the cysts of *E. coli* (*Annals*, Vol. XII, p. 259), and traced the course and duration of an infection with this parasite (*Annals*, Vol. XIII, p. 17). Matthews and Smith investigated the spread and incidence of intestinal protozoal infections in the population of Great Britain. The first selected population consisted of four hundred and fifty civilians in the Liverpool Royal Infirmary (*Annals*, Vol. XII, p. 349), of which 1·5 per cent. were found to harbour *E. histolytica* and 6·7 per cent. *E. coli*. The figures for army recruits, of which one thousand and ninety-eight cases were examined, were *E. histolytica* 5·6 per cent., *E. coli* 18·2 per cent., *E. nana* 2·4 per cent., *G. intestinalis* 6·0 per cent., and *C. mesnili* two cases. In five hundred and forty-eight children, all under the age of twelve (*Annals*, Vol. XII, p. 361), *G. intestinalis* was the parasite most commonly found. Of two hundred and seven male asylum patients (*Annals*, Vol. XIII,

p. 91), 9·7 per cent. were found to be infected with *E. histolytica*, 45·9 per cent. with *E. coli*, and 23·2 per cent. with *C. mesnili*. University and School cadets were also examined; the same protozoa were found as amongst other series, but the number of cases recorded was too small to allow of conclusions being drawn as to incidence amongst this higher social class.

In 1906, Drs. Fantham and Porter investigated the Isle of Wight bee disease (*Annals*, Vol. VI, p. 163). It was found that the disease was due to a minute microsporidian parasite, *Nosema apis*, sp. n., which gained access by the mouth to the intestines. Experimental work proving the pathogenicity of the parasite was carried out. It was found that *Nosema apis* was harboured by other insects besides the hive bees (*Annals*, Vol. VII, p. 569). It was considered that a bee, itself apparently immune, can be a parasite carrier. A morphological study of *Nosema apis* was made, and the two phases in its life cycle demonstrated: (1) a multiplicative phase, termed merogony, which occurs in the epithelium of the chyle stomach and intestines of the bee; (2) a second phase, termed sporogony, leading to the formation of minute, resistant resting spores, which are shed in the faeces of the bee, fouling the surroundings of the hive and producing infection of fresh bees when swallowed in food or drink. An allied organism, *Nosema bombi*, sp. n., parasitic in, and pathogenic to, bumble bees, was discovered, and its life cycle, and suggested economic measures of control, set forth in a subsequent paper (*Annals*, Vol. VIII, p. 623).

9, 111,767 persons were found to be infected with [illegible] 4.9 per cent. with [illegible], and 13.2 per cent. with [illegible] [illegible] and School [illegible] respectively. [illegible] patients were found [illegible] other [illegible], but the number of cases recorded was too small [illegible] conclusions as being [illegible] to conclusions among the higher [illegible].

In 1926, Drs. [illegible] and Carter investigated the [illegible] the disease of [illegible]. It was found that the disease was due to a [illegible] as a, which [illegible] the [illegible] of [illegible] pathogenicity of the [illegible] was [illegible]. It was found that [illegible] was [illegible] in the [illegible], Vol. VII, [illegible]. It was found that in [illegible] as [illegible] morphological study of [illegible], and the [illegible] in the life cycle [illegible] [illegible] in the [illegible] of the [illegible] [illegible] and [illegible] leading to the formation of [illegible] in the [illegible] of the [illegible] or death. [illegible] and [illegible] in [illegible] and [illegible] and morphological [illegible] [illegible] (Annals, Vol. VIII, pp. [illegible]).

ON THE 'ARNETH COUNT' IN HOOKWORM-INFECTED WHITE CHILDREN IN NORTH QUEENSLAND

BY

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In the past, work has been carried out by Breinl and Priestly (1914) on Arneth counts of healthy white school children, who had spent their lives in the tropical parts of North Queensland. The observations proved a decided shift of the Arneth index to the left, when compared with that of normal individuals in Europe. Later, this investigation was extended to healthy aboriginal children in Northern Australia (1917), and, furthermore, to native children in New Guinea (1915), living in an area where malaria, yaws and other parasitic diseases were found to be endemic.

A shift of the Arneth index to the left was found in healthy aboriginal children of North Queensland analogous to that of children of European descent in North Queensland, but a much more pronounced shift was found in the native children of New Guinea.

Taking advantage of recent opportunities, blood smears obtained from white children in North Queensland, suffering from ancylostomiasis were examined in order to determine the Arneth index. A number of the smears were collected by one of the members of the staff of the hookworm campaign, carrying out work at present in North Queensland; others were obtained from children of various ages, who underwent treatment for hookworm infection in the Townsville Hospital.

Previous observations by Knapp (1915) in India showed in the blood of hookworm patients a distinct shift of the Arneth index to

the right, but the results, according to his own statement, 'were on the whole equivocal,' and he proposed to carry out further research.

Macfie (1916), working on the Gold Coast, confirmed to a certain extent Knapp's tentative results. Out of seventeen counts made on hookworm patients, about 30 per cent. showed, when compared with those of healthy natives, an actual shift to the right, 41 per cent. had a relative shift to the right, that is, 'a slighter degree of shift to the left than is found in apparently healthy natives,' and 29 per cent. had a definite shift to the left. He concluded from his results that 'there appeared unquestionably a tendency to develop a shift to the right in patients infected with hookworms.'

In the present investigation the same technique was employed as in the previous work; all counts were performed by myself, Dr. Priestly and myself having performed the previous counts. In this way the results, so far as technique is concerned, are comparable with those obtained previously, and the personal source of error has been, so far as possible, excluded.

Two hundred consecutive leucocytes were counted in two sets of 100, and only when the two sets of figures differed but slightly were the counts taken into consideration.

All the children from whom the blood was obtained lived in areas where malaria is practically unknown, and any definite change found must be attributed to the effects of hookworm infection.

The figures (Table I) were separated according to age groups, and the table shows that the averages for the age groups between five and fifteen years are fairly constant. The Arneth index for children two and three years old is much lower, and approaches that found in healthy North Queensland children. The disproportionate rise for children four years of age may be due to the small number of observations. The total averages prove conclusively that the average Arneth index in hookworm-infected children shows a decided shift to the left.

A comparison of the Arneth index of hookworm-infected white children in North Queensland with that of children living in New Guinea shows a striking similarity, and strengthens the assumption that the comparative increase in the Arneth index in the latter locality was due to the great incidence of latent and active infection

TABLE I.

Age	Number of children	Arneth Classication % I	II	III	IV	V	Arneth Index	Differential Counts % Poly-morpho-nuclear neutro-phile	Transi-tionals	Large Mono-nuclear	Lympho-cytes	Eosino-philes	Mast cells
years 2	3	30·0	42·5	24·0	3·0	0·5	72·5	38·9	2·7	0·8	44·0	12·41	0·2
3	4	31·0	44·4	18·9	5·2	0·5	75·4	36·1	3·5	0·8	41·1	17·9	0·6
4	2	61·0	34·5	4·3	0·2	—	95·5	41·6	5·5	0·7	29·6	22·1	0·5
5	5	41·3	40·5	15·7	2·4	0·1	81·8	46·98	3·04	0·70	32·78	15·74	0·76
6	12	42·42	40·66	13·87	2·95	0·1	83·08	49·10	2·54	0·52	34·28	12·75	0·81
7	17	42·91	39·95	14·56	2·53	0·05	82·86	54·33	3·01	0·61	30·99	10·72	0·34
8	11	43·81	41·51	12·46	2·18	0·04	85·32	46·31	3·01	0·39	35·74	14·15	0·40
9	14	41·65	41·72	13·90	2·53	0·20	83·37	56·59	2·94	0·88	28·77	10·32	0·50
10	11	45·00	40·09	13·23	1·54	0·14	85·09	58·13	2·61	0·45	27·04	11·34	0·43
11	9	41·12	42·39	13·83	2·66	—	83·51	53·89	2·71	0·32	25·79	16·65	0·64
12	12	42·75	40·50	14·42	2·29	0·04	83·25	57·79	2·74	0·55	29·22	9·22	0·48
13	8	39·94	43·06	14·56	2·31	0·13	83·00	53·62	3·17	0·46	31·74	10·28	0·73
14	9	39·77	40·61	15·89	3·34	0·39	80·38	49·39	3·87	0·61	35·10	10·23	0·80
15	4	45·50	41·50	11·25	1·75	—	87·00	48·62	3·03	0·50	34·43	12·92	0·50
2 to 15	121	42·11	41·05	14·20	2·51	0·13	83·16	51·88	3·00	0·58	31·75	12·22	0·57
Native children of New Guinea, aged 1-10 years	50	42·96	40·90	13·80	2·13	0·21	83·86	40·96	2·47	1·36	42·86	13·24	—
North Queensland school children (white) 7-15 years	150	32·50	42·0	20·6	4·5	0·4	74·5	56·1	4·2	2·4	29·5	7·7	0·04

the right, but the results, according to his own statement, 'were on the whole equivocal,' and he proposed to carry out further research.

Macfie (1916), working on the Gold Coast, confirmed to a certain extent Knapp's tentative results. Out of seventeen counts made on hookworm patients, about 30 per cent. showed, when compared with those of healthy natives, an actual shift to the right, 41 per cent. had a relative shift to the right, that is, 'a slighter degree of shift to the left than is found in apparently healthy natives,' and 29 per cent. had a definite shift to the left. He concluded from his results that 'there appeared unquestionably a tendency to develop a shift to the right in patients infected with hookworms.'

In the present investigation the same technique was employed as in the previous work; all counts were performed by myself, Dr. Priestly and myself having performed the previous counts. In this way the results, so far as technique is concerned, are comparable with those obtained previously, and the personal source of error has been, so far as possible, excluded.

Two hundred consecutive leucocytes were counted in two sets of 100, and only when the two sets of figures differed but slightly were the counts taken into consideration.

All the children from whom the blood was obtained lived in areas where malaria is practically unknown, and any definite change found must be attributed to the effects of hookworm infection.

The figures (Table I) were separated according to age groups, and the table shows that the averages for the age groups between five and fifteen years are fairly constant. The Arneth index for children two and three years old is much lower, and approaches that found in healthy North Queensland children. The disproportionate rise for children four years of age may be due to the small number of observations. The total averages prove conclusively that the average Arneth index in hookworm-infected children shows a decided shift to the left.

A comparison of the Arneth index of hookworm-infected white children in North Queensland with that of children living in New Guinea shows a striking similarity, and strengthens the assumption that the comparative increase in the Arneth index in the latter locality was due to the great incidence of latent and active infection

TABLE I.

Age	Number of children	ARNETH CLASSICATION % I	II	III	IV	V	Arneth Index	DIFFERENTIAL COUNTS % Poly-morpho-nuclear neutro-phile	Transi-tionals	Large Mono-nuclear	Lympho-cytes	Eosino-philes	Mast cells
years 2	3	30·0	42·5	24·0	3·0	0·5	72·5	38·9	2·7	0·8	44·0	12·41	0·2
3	4	31·0	44·4	18·9	5·2	0·5	75·4	36·1	3·5	0·8	41·1	17·9	0·6
4	2	61·0	34·5	4·3	0·2	—	95·5	41·6	5·5	0·7	29·6	22·1	0·5
5	5	41·3	40·5	15·7	2·4	0·1	81·8	46·98	3·04	0·70	32·78	15·74	0·76
6	12	42·42	40·66	13·87	2·95	0·1	83·08	49·10	2·54	0·52	34·28	12·75	0·81
7	17	42·91	39·95	14·56	2·53	0·05	82·86	54·33	3·01	0·61	30·99	10·72	0·34
8	11	43·81	41·51	12·46	2·18	0·04	85·32	46·31	3·01	0·39	35·74	14·15	0·40
9	14	41·65	41·72	13·90	2·53	0·20	83·37	56·59	2·94	0·88	28·77	10·32	0·50
10	11	45·00	40·09	13·23	1·54	0·14	85·09	58·13	2·61	0·45	27·04	11·34	0·43
11	9	41·12	42·39	13·83	2·66	—	83·51	53·89	2·71	0·32	25·79	16·65	0·64
12	12	42·75	40·50	14·42	2·29	0·04	83·25	57·79	2·74	0·55	29·22	9·22	0·48
13	8	39·94	43·06	14·56	2·31	0·13	83·00	53·62	3·17	0·46	31·74	10·28	0·73
14	9	39·77	40·61	15·89	3·34	0·39	80·38	49·39	3·87	0·61	35·10	10·23	0·80
15	4	45·50	41·50	11·25	1·75	—	87·00	48·62	3·03	0·50	34·43	12·92	0·50
2 to 15	121	42·11	41·05	14·20	2·51	0·13	83·16	51·88	3·00	0·58	31·75	12·22	0·57
Native children of New Guinea, aged 1-10 years	50	42·96	40·90	13·80	2·13	0·21	83·86	40·96	2·47	1·36	42·86	13·24	—
North Queensland school children (white) 7-15 years	150	32·50	42·0	20·6	4·5	0·4	74·5	56·1	4·2	2·4	29·5	7·7	0·04

amongst children, amongst whom hookworm infection is probably widespread.

The significance of the shift of the Arneth index to the left is still uncertain. It is, however, possible that in such diseases as hookworm infection and malaria, where the destruction of red cells goes, for a time at least, hand in hand with an increased activity of the blood-forming organs, the increased activity extends to the new formation of leucocytes, and in consequence a greater number of young leucocytes are met with in the peripheral blood.

The differential counts indicate that in younger children—between two and four years of age—the relative number of polymorphonuclear neutrophile leucocytes is decreased, whereas that of the lymphocytes is increased.

After the seventh year the relative proportion of the various forms of white blood corpuscles is fairly constant.

As is to be expected, the relative increase in the number of eosinophile leucocytes is well pronounced throughout our series of counts.

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BRONCHOMONILIASIS COMPLICATING PULMONARY TUBERCULOSIS IN A NATIVE OF THE GOLD COAST, WEST AFRICA

BY

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AND

A. INGRAM

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Since Castellani discovered the condition in Ceylon in 1905, bronchomoniliasis has been identified in many parts of the world, especially in tropical and sub-tropical countries. In Africa, Chalmers and Macdonald (1920) studied a number of cases in the Sudan and Egypt, and Pijper (1917) has noted the presence of the disease in South Africa, but, so far as we are able to ascertain, no cases have hitherto been recorded from West Africa. For this reason, a short account will be given of a case which has recently come under our notice at Accra, in the Gold Coast, West Africa. The case was not a pure bronchomoniliasis, but occurred in a patient suffering from pulmonary tuberculosis, a form of mixed infection which apparently is not uncommon, and has been observed previously by de Mello and Fernandes, Castellani and Chalmers, and others.

History. We are indebted to Dr. J. R. Moffatt for the following history of the case. I. D., a native (Buzaburime), aged about twenty-five years and a member of the Police Force, admitted to the Native Hospital, Accra, on the 29th of September, 1920. The patient stated that he had suffered severely from cough for at least two months previous to admission. Upon being closely questioned, he further admitted that for at least eighteen months he had experienced attacks of illness, accompanied by cough, at irregular intervals. Physical examination revealed dullness at the apex of the right lung, chiefly supra-clavicular; at the base of the left lung there was a considerable area of dullness extending as high as the

angle of the scapula, and at its upper portion, especially on the anterior aspect, bounded by a hyper-resonant area. The cough was frequent and harrassing; the sputum copious and in appearance like thin flour paste. Sweating was inconsiderable. Although the breathing was rapid, the patient never suffered from dyspnoea. The temperature chart kept whilst the patient was in hospital showed an irregular fever similar to that which might have been expected in a case of pulmonary tuberculosis. The treatment given was cod-liver oil and, for a few days only, potassium iodide. During the last two weeks of his illness the patient showed some improvement and gained weight; on the night of the 8th of November, however, he had a sudden and copious haemoptysis and died within an hour.

A specimen of the sputum of this case was forwarded to the laboratory for examination as to the presence of tubercle bacilli upon the 30th of September; none were found on this occasion, but it was noted that the sputum had a curious appearance, suggestive of saliva containing small particles of macerated bread, and accordingly another specimen was asked for which should be taken after thoroughly washing the mouth with a weak antiseptic solution. On the 2nd of October the second specimen of the sputum was examined, and was found to contain numerous yeast-like cells (*Monilia* sp.) but no tubercle bacilli. Cultures were made from this specimen of the sputum upon Sabouraud's maltose agar and glucose agar, and within twenty-four hours a copious creamy-white growth of the Monilia had made its appearance on both media. On the 5th of October the sputum again showed yeast-like Monilia cells and also a few coarse hyphae; tubercle bacilli were not detected. As potassium iodide has proved a valuable remedy in broncho-moniliasis, it was suggested that it should be tried in this case, and this was done for a few days, ten grains being given thrice daily. The effect was to reduce the number of Monilia cells in the sputum very greatly, and to reveal the presence of tubercle bacilli which in all probability had been overlooked at previous examinations. A specimen of the sputum examined on the 8th of October showed very numerous tubercle bacilli and no Monilia cells, and as the potassium iodide appeared to be causing the patient some discomfort, owing to the increase in the quantity of his sputum, it was then stopped. Sputum examined on the 14th of October, and

later, showed that the Monilia cells had reappeared and that the number of tubercle bacilli appeared to be fewer. The patient died on the 8th of November as the result of an haemoptysis, and a post-mortem examination of the body was made on the following morning.

Post-mortem Examination. The following were the notes made at the examination. Body: that of a young native man, rather emaciated. Abdominal cavity and its contents: appeared to be normal. Spleen: not enlarged, weight seven and a half ounces, no visible morbid condition. Kidneys and liver: showed venous engorgement but no other pathological signs. Gall bladder: collapsed, empty. Mesenteric glands: not enlarged. Right lung: adherent to the chest wall at its apex; on removal and section a cavity about the size of a walnut was found at the apex, it contained a blood clot; the whole of the upper lobe and a portion of the middle studded with small tubercles. Left lung: completely collapsed, visceral and parietal pleurae very greatly thickened and of a creamy-yellow colour; the pleura covered in parts with a deposit of the colour and consistence of cream cheese, the pleural cavity contained about four ounces of turbid straw-coloured fluid; the substance of the lung studded with numerous caseating tubercular nodules, and at one point apparently communicating with the pleural cavity. Lymphatic glands at the root of the neck and in the mediastina: enlarged, tuberculous.

Smears of the creamy exudate in the left pleural cavity showed numerous tubercle bacilli and yeast-like Monilia cells, also a considerable number of short septate branching hyphae. Sections of the lungs showed that both were the seat of advanced tubercular disease; sections of the thickened pleura of the left lung and of a mass of the pleural exudate showed also the presence of Monilia.

Organism. The Monilia found in this case was easily obtained in pure culture by inoculating tubes of Sabouraud's maltose agar and glucose agar. It was gram-positive but not acid fast. It grew well on most solid media, but especially well on glucose agar, and produced rapidly a diffuse, spreading, creamy-white growth. Under anaerobic conditions its growth was slower. Gelatin and blood serum were not liquified by it, and did not become pigmented. In broth and peptone water it caused a white deposit to be thrown

down whilst the media themselves remained clear; in peptone water a slight surface pellicle was formed. It produced a thick white growth on potato. On solid media the growth was almost entirely composed of yeast-like cells; in some fluid media hyphae predominated.

Its qualitative bio-chemical reactions may be tabulated as follows:—

Arabinose	O	Inulin	O
Rhamnose (isodulcite)	O	Amygdalin	O
Galactose	AG	Helicin	O
Glucose	AG	Phlorrhizin	O
Laevulose	AGs	Salicin	O
Mannose	O	Glycerol	O
Lactose	O	Erythrol	O
Maltose	AGs	Adonitol	O
Saccharose	AG	Dulcitol	O
Amylum	O	Inosite	O
Dextrin	O	Mannitol	O
Glycogen	O	Sorbitol	O

The symbols representing: A—acid; G—gas; s—slight; and O—neither acid nor gas.

The production of gas in laevulose and maltose was slight. If the cultures were kept for two weeks or longer the acidity produced in the five sugary media indicated tended to be superseded by alkalinity; this was earliest seen and most pronounced in glucose and saccharose. At first no change was produced in litmus milk, but later, after about ten days, alkalinity developed; no clot was formed and the medium was neither decolourised nor peptonised. Indol was not produced in peptone water.

As gas was produced in glucose, laevulose, maltose, galactose, and saccharose, the organism comes into the fifth group of species of *Monilia*, called the *Tropicalis group*, according to the classification of Castellani and Chalmers (1919). In this group are placed (*loc. cit.* p. 1084) *M. tropicalis*, Cast., *M. paratropicalis*, Cast., *M. pulmonalis*, Cast., *M. nivea*, Cast., *M. insolita*, Cast., and *M. enterica*, Cast.; but from the table given by the same authors (pp. 1082-1083) it would appear that *M. faecalis*, Cast., and *M. metatropicalis*, Cast., should also be included. A somewhat later table given by Castellani (1920) differs slightly from that given by Castellani and Chalmers and omits certain species whilst intro-

ducing some additional ones. According to it, acid and gas are produced in the five sugary media mentioned by five species only, namely, *M. enterica*, *M. faecalis*, *M. metatropicalis*, *M. paratropicalis*, and *M. tropicalis*.

Reverting to the species given by Castellani and Chalmers, which include the five given by Castellani alone and three others, it will be seen that the bio-chemical reactions of the organism isolated from our case do not agree entirely with those of any of them (see table). The reaction in litmus milk suffices to distinguish it from

Table showing the more important biochemical reactions of the species of *Monilia* of the *Tropicalis group*.

Species of *Monilia*	Litmus milk	Glucose	Laevulose	Maltose	Galactose	Saccharose	Mannite	Dextrin	Raffinose	Arabinose	Broth
M. enterica	O/Alk	AG	AG	AG	AG	AG	As	As	O	O	C
M. faecalis	A/DPs	AG	AG	AG	AGs	AGs	O	O	O	O	C
M. insolita	As/Alk	AG	AG	AG	AG	AG	As	O	O	O	C
M. metatropicalis	AC	AG	AG	AG	AG	AG	O	O	O	O	C
M. nivea	O/Alk	AG	AG	AG	AG	AGs	O	O	AG	O	C
M. paratropicalis	As/Alk	AG	AG	AG	AG	AG	O	Avs	O	O	CTP
M. pulmonalis	O/AlkD	AG	AG	AG	AGs	AG	Avs	O	A	AGs	CTP
M. tropicalis	A	AG	AG	AG	AGs	AGs	O	O	O	O	C
Species isolated from case of Bronchomoniliasis at Accra	O/Alk	AG	AGs	AGs	AG	AG	O	O	?	O	C

A = acid ; G = gas ; s = slight ; vs = very slight ; O = neither acid nor gas produced ; Alk = alkalinity ; C = clot ; D = decolourisation ; C = clear ; CTP = clear thin pellicle ; P = peptonisation.

all the other species of the *Tropicalis group* excepting *M. enterica* and *M. nivea*. The former of these two produces slight acidity in mannitol and dextrin, reactions which are not produced by our species. As regards the latter, *M. nivea*, acid and gas are produced

in raffinose, and acid but only a small amount of gas in saccharose. We were unable to test the reaction of our species in raffinose, but in saccharose much gas was produced, and only a small amount in laevulose and maltose. It is admitted, however, that many of the species of the Genus *Monilia* have not permanent bio-chemical reactions, a point emphasised by Castellani himself, and if they are liable to vary outside the body, it seems not unlikely that they may vary also according to their host. The very slight differences noted between the bio-chemical reactions of the organism recently isolated by us and those of *M. nivea* are, therefore, probably unimportant.

M. nivea was originally found in sputum, and is considered by Castellani and Chalmers to be of doubtful pathogenicity. It is of interest, therefore, to recall that the organism resembling this species which we have isolated was found not only in the sputum but also, after death, in the body of the patient.

SUMMARY

A case is recorded in which bronchomoniliasis complicated pulmonary tuberculosis in a native of the Gold Coast at Accra.

The patient died of an haemoptysis whilst under observation. At the post-mortem examination both lungs were found to be tuberculous. The left lung was collapsed, and the pleural cavity partially filled with exudate. In this exudate and in the thickened pleura over the lung Monilia was present.

The organism, which belonged to the *Tropicalis group* of Castellani and Chalmers, closely resembled in bio-chemical reactions *M. nivea*, Cast. (1910); without raffinose we are unable to state whether the species found at Accra is distinct from *M. nivea*, Cast.

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NOTES ON A CASE OF INDIGENOUS INFECTION WITH *P. FALCIPARUM*

BY

B. BLACKLOCK

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In their preliminary note on this case, Glynn and Matthews (1920) have furnished an account of the findings at the post-mortem examination and also details of the history. For convenience we may recapitulate here briefly the main facts.

History. The patient was a girl, aged 18, who had never been out of the British Isles; she was born in Liverpool and had once been South—to London in 1914, from July to September, during which period she spent three weeks at Littlehampton; she had lived for the last ten years in the same house in Liverpool. She died on October 12th, 1920, after a period of illness which commenced (on her return from a holiday in a northern health resort) with 'feverishness and flushed appearance' on October 1st, followed on October 2nd and 3rd and several other occasions by vomiting. On October 8th she was overcome with faintness in the street, and had to be helped home. Her condition rapidly became worse with severe headache, thirst, photophobia, delirium, paresis of legs, anuria, and finally coma. The temperature on October 11th, the day before death, was 100° F., and on October 12th, just before death, 102° F. Further investigation elicited the facts that she had always been pale, had suffered from headaches since Christmas, 1919, and that she had vomited on September 29th, 1920.

The following notes on the post-mortem examination are quoted from the paper mentioned above:—

'The post-mortem examination was made twenty hours after death. ***Blood:*** anaemic. ***Brain:*** apparently normal, no meningitis. ***Lungs:*** a moderate amount of oedema and muco-purulent bronchitis. ***Heart:*** weight, 8 oz., normal, no fatty degeneration. ***Mouth:*** healthy, no trace of pyorrhoea. Oesophagus, stomach and intestines opened from end to end—normal, no evidence of blood. Some of the lumbar lymphatic glands slightly enlarged, and red like haemolymph glands. ***Liver:*** weight, 3 lbs., slightly browner than normal, no haemosiderin reaction. ***Spleen:*** 1 lb. 7 oz., retains its shape, of normal consistency, but dark, rather like

malaria. Pancreas, suprarenals, kidneys and bladder normal. *Uterus:* normal size, but menstruating; one haemorrhagic corpus luteum. Bone marrow of the shaft of the femur a uniform terra-cotta red, that of the sternum redder and more succulent than normal.'

The following is a short account of my observations on the material examined. It is convenient to state here that the specimens from this case, which were demonstrated by me at a meeting of the Royal Society of Tropical Medicine and Hygiene, were by some inadvertence included under Col. James's exhibits, and erroneously stated to have been derived from a case in Sheerness. (See *Lancet*, January 1st, p. 26.)

Blood film. About a third of the red corpuscles contained young trophozoites, but owing probably to post-mortem changes the parasites appeared small and contracted, giving an appearance similar to that seen in sections. Not only was the total number of red cells infected large, but also multiple infection was common, many cells containing two, three, four, up to five parasites. Gametocytes were present in small numbers most of them being fully developed crescents, some of them presenting a peculiar appearance owing to the red cell being visible all round the parasite and extending some distance beyond it, and not chiefly in the concavity of the crescent; other forms were oval or spherical, and in addition there were seen solid-looking parasites of irregular outline which might be interpreted as developing forms of gametocyte. A small number of segmenting forms with a number of merozoites varying from ten to twenty-four also occurred in the blood, the crescents and fully divided forms being in about equal proportion.

Nucleated red cells were numerous, as was observed in the preliminary note, the figure given being 3·8 nucleated reds to 100 leucocytes (500 counted), while my figure is slightly higher, 4·9 to 100 leucocytes (1,000 counted). They presented much diversity in the form of the nucleus, single-nucleated forms predominating, but forms with double and multipartite nuclei also being found. Pigment was present in mononuclear leucocytes and also free in the plasma, some in the latter possibly being due to the breaking of segmenting forms in making the film.

Spleen smear. The chief feature to attract attention was the occurrence of very numerous segmenting forms, not all at the same

stage of sub-division, the merozoites numbering from eight to twenty-two. There were a few crescentic, oval, and spherical gametocytes. An occasional parasite, even in the segmenting stage, was found ingested by phagocytes. Pigment, both black and golden yellow, was present in considerable amount, ingested by large mononuclear white cells.

Bone marrow smear. Here crescentic and oval forms of gametocyte were numerous in quite different proportions to the numbers in either the blood or spleen smears. A few segmenting forms occurred and many small trophozoites, of which some were free. Among the large mononuclear cells, many were observed which contained eosinophil granules, and many also containing pigment.

Several questions of interest arise in connection with this case, and it is necessary, in spite of the limited character of the observations made on the case during the period of her illness and the small amount of material available for examination, to endeavour to answer some of the questions.

1. Was this a primary acute attack following directly the incubation period, or a secondary acute attack supervening in a person already infected for a considerable time?
2. By what means did the patient acquire infection?
3. At what time and where did she become infected?

I. WAS THIS A PRIMARY OR SECONDARY ACUTE ATTACK?

(*a*) *Primary acute attack.*

The absence of any history, previous to October 1st, 1920, of fever, shivering or sweating, is in favour of this being a primary acute attack.

Spleen. Support is also lent to this theory by certain appearances presented by the spleen. The noteworthy condition seen in section of this organ is the remarkable congestion, with dilatation of the sinuses. These facts are illustrated by photograph I, representing a section from the spleen of the case under discussion. That the large size of the spleen is due to a recent enlargement of the organ is further demonstrated when we observe that the increase of size is due to engorgement with blood and not to increase of fibrotic tissue, nor to the cellular elements of the spleen itself.

(*b*) *Secondary acute attack.*

It is quite possible for a person to harbour and present for considerable periods in his blood *P. falciparum* without the production of definite signs and symptoms, provided the person is taking quinine or other drugs. This fact has been observed frequently, and instances will be found in the work of Stephens and his collaborators (1917). Similarly it is recognised that persons suffering from relapses of malignant tertian malaria may have parasites present in the peripheral blood for varying periods before

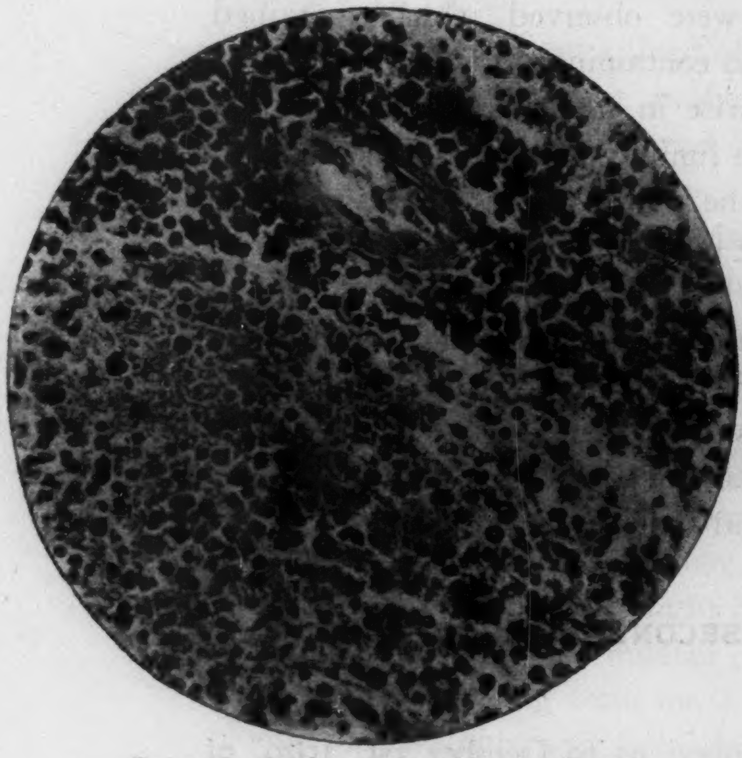

PHOTO. I. Section of the spleen showing the Malpighian body with vessel cut obliquely and below it the accumulation of red blood corpuscles. × about 280.

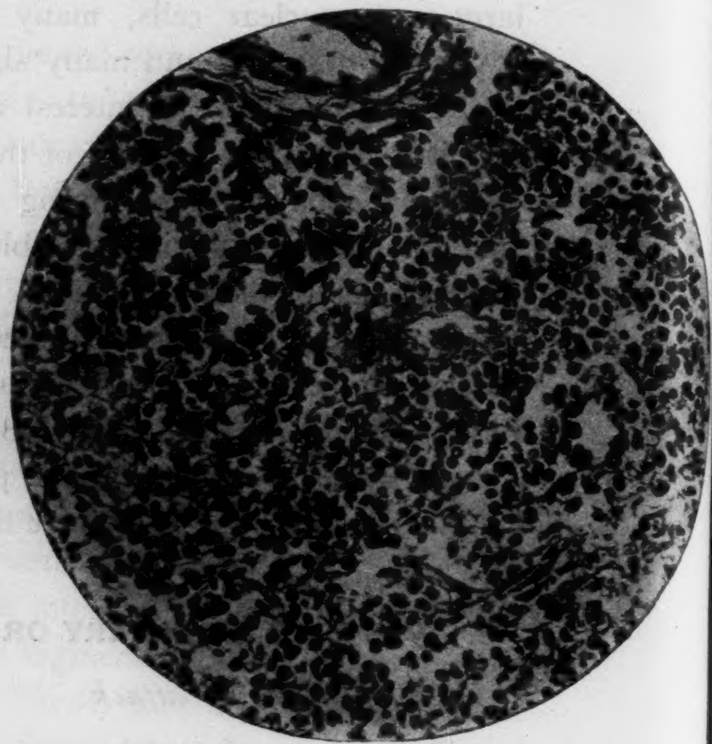

PHOTO. II. Section of normal spleen. × about 280.

Photographs lent by Professor Glynn

the next attack occurs. But it is also possible that a person who is infected may, even if untreated, remain without definite signs or symptoms for a long period and then suddenly develop an acute attack; instances of incubation periods up to 'months' are mentioned by Craig (1914). It should be observed, however, that in experimental infections in which healthy persons are injected with blood containing parasites or are bitten by anophelines containing sporozoites in their salivary glands, such long incubation periods are not recorded. Ross, whose contribution to the elucidation of

this case is dealt with more fully below, does not supply information which is of assistance concerning this point. In the case under consideration the only evidence of old standing symptoms or signs which might possibly be attributed to malaria are that the girl had suffered from headaches from Christmas, 1919, her pallor, and the fact that she vomited on September 29th. With regard to these phenomena, they may be attributed to so many other causes that they can give us no clue.

Spleen. The features which may be regarded as indicative of chronicity are the size (644 grms.) and lack of diffluence. As regards the former, Dudgeon and Clarke (1918-19) give the weight of the spleen in a series of fatal cases of pernicious malaria due to *P. falciparum* as varying from 250 to 450 grms.; the highest weight in a chronic case was 960 grms. On the other hand, James (1920) emphasises the great splenic enlargement observed in indigenous cases of simple tertian malaria in children. Previously Osler (1901) mentioned a case of death from accident during the second week of simple tertian malaria where the spleen weighed 800 grms., was very dark red, and diffluent.

II. BY WHAT MEANS DID THE PATIENT ACQUIRE INFECTION?

The two known methods by which it is possible to transmit malaria to a healthy person are the inoculation of infected blood and the transmission by the bite of a mosquito with infected salivary glands. The incubation period, using such methods, varies considerably for malignant tertian parasites, and it is necessary to enquire into the periods and how they are estimated.

The inoculation of Infected Blood into Healthy Persons

Of the numerous records obtained by inoculating blood containing malaria parasites into healthy persons only a small number is concerned with the malignant tertian parasite. Some of the early experiments collected by Thayer and Hewetson (1895) are, for comparative purposes, set out here in tabular form.

It will be seen from Table I that in the early experiments the parasite incubation was long. These early experiments are, however,

open to several objections. In Gualdi and Antolisei's first two experiments the inoculation of blood from quartan patients resulted in the appearance, in the subjects of inoculation, of malignant tertian parasites. The authors had to account for this by discovering later that the patient whose blood was inoculated harboured both forms of parasite. In the third case recorded by Gualdi and Antolisei, and that of Di Mattei, crescents only were visible in the blood injected, while in the last case, that of Sacharow, not only was the injection small in amount and given subcutaneously, but also the blood was taken from leeches which had been fed four days previously on the infected person and which, since feeding, had been kept on ice.

Table I.

Plasmodium falciparum. Incubation period following blood inoculation. Early experiments.

Observer	Route of Injection	Amount of Blood injected c.c.	Day on which, in inoculated person		Remarks
			Fever commenced	Parasites appeared	
Gualdi and Antolisei	Intravenous ...	3	10	10	Source of blood, quartan cases.
Gualdi and Antolisei	Intravenous ...	3	12	12	Source of blood, quartan cases.
Gualdi and Antolisei	?	2	9	10	Crescents only found in blood injected. Crescents seen in inoculated person in 18 days.
Di Mattei	Intravenous ...	?	16	In a few days after injection	Crescents only found in blood injected. Crescents seen in inoculated person in 25 days.
Sacharow	Subcutaneous	1	12	13	Blood kept in leeches on ice 4 days before injection.

Experiments were performed later by Bastianelli and Bignami, which are set out in Table II, and from this series a very different idea of the incubation period following inoculation is obtained. Parasites appeared in the peripheral blood in so short a period as two days after injection of 2 c.c. of infected blood, and infection resulted after such small quantities as 0·2 c.c. of blood injected. No mention is made as to the date of crescents appearing in the blood in these cases.

It appears, then, that the incubation period after experimental inoculation, whether as regards occurrence of fever or appearance of parasites in the blood, may be exceedingly brief in malignant tertian malaria.

Ross (1920) has suggested the possibility of this case having acquired infection by inoculation of blood. There was no evidence in the history of the case that such a mode of infection could have been the cause. She had cocaine injections for removal of teeth in July, 1919, and in February, 1920; for the removal of the teeth, mentioned as done on 14th September, 1920, the anaesthetic used was ether, and no evidence was obtained either that any such injections as morphia had been given, or that infection could have

Table II.

Plasmodium falciparum. Incubation period following blood inoculation. Later experiments.

Observer	Route of Injection	Amount of blood injected c.c.	Day on which, in inoculated person		Remarks
			Fever commenced	Parasites appeared	
Bastianelli and Bignami ...	Intravenous ...	2·0	2	2	
	...	5·0	2	2	Few parasites seen in injected blood.
	...	0·75	5	?	Few parasites seen in injected blood.
	...	0·2	4	?	Fair number of parasites seen in injected blood.

arisen from abrasions of skin or mucous membranes having facilitated transmission. It is regrettable that Ross, who has sources of information inaccessible to others, should not have communicated the facts in such a form as to have added to our knowledge of the various points of interest which must have arisen as the result of his observations. The incubation period of malignant tertian malaria under such circumstances, the dates of the first appearance of symptoms and parasites, and also the important question as to the time of the appearance of crescents, are all matters of sufficient interest to make welcome any additional facts relating to them.

Incubation period of P. FALCIPARUM *following the Bites of Infected Anopheline Mosquitoes*

The records of experiments of this nature do not comprise numerous observations, and in some cases the data given are insufficient for our present purpose. In Table III are shown the results of some experiments in which more complete data are given by the observers.

TABLE III.

Plasmodium falciparum, incubation period following the bites of anophelines previously infected.

Observer	Anopheline used	Wild or Bred	Healthy individual: Number of mosquitoes fed	Number of days they were fed	Fever commenced in days	Parasites appeared in days	Temperature at which mosquitoes kept	Remarks
Bastianelli and Bignami (1899)	*A. maculipennis* ...	Wild ...	3–2	2	9–12	10–13	30° C.	The person on w[illegible] the mosquitoes [illegible] infected develo[illegible] Simple Tertian Malaria in 17-1[illegible] days.
Schüffner (1901) ...	*A. vagus*	Wild ...	?	2	15–16	17–18	Room	Large rings found[illegible]
Jancsó (1908) ...	*A. maculipennis* ...	Wild ...	2	1	12	12	24° C.	Quinine, 1 gm. on [illegible] day after bites.
Jancsó (1908) ...	*A. maculipennis* ...	Wild ...	1	2	10–15	11–16	20° C.	Quinine given [illegible] first bite, 1 [illegible] 1 gm., 1·5 [illegible] 1·5 gm., on [illegible] 9th, 10th, 11th [illegible] respectively.
Mitzmain (1916) ...	*A. quadrimaculatus*	Bred ...	1	1	10	10	21–22° C.	Accidental infecti[illegible]

In these experiments the maximum parasitic incubation period of *P. falciparum* after infection by means of bites of infective anophelines is eighteen days, the minimum ten days.

Before accepting the results of these observers, however, it is necessary to enquire more closely whether they are justified in regarding the experiments as conclusive. In Bastianelli and Bignami's experiment wild *A. maculipennis* were fed, for the purpose of infecting them, on a patient suffering from malignant tertian fever; this patient after seventeen to nineteen days from the commencement of feeding the mosquitoes on him showed in his blood the parasites of simple tertian fever. If the wild mosquitoes

infected him with *Plasmodium vivax* it appears not improbable that they might also infect with *P. vivax* the healthy person on whom they fed, and, therefore, one would expect that corroborative evidence such as the date of appearance of crescents in this case should be given. Apart from this, there is evidence, in some of these records, that the population used for experiment was subject to multiple infection. Reference has already been made to the fact that Gualdi and Antolisei, using the blood of patients supposed to be carrying *P. malariae*, obtained in the person injected *P. falciparum* This may be capable of many explanations, even excluding Laveran's theory, recently revived by Grassi (1920), of the unicity of the parasite, for example that they conveyed the parasite of malignant tertian fever by the inoculation, or that the person inoculated was himself already suffering from infection with *P. falciparum* or that he acquired such infection from mosquitoes independently of the inoculation. In the same way, in Bastianelli and Bignami's case, additional evidence as regards the species of parasite recovered is not available. In Jancsó's experiments the administration of quinine may have influenced the incubation perod. Mitzmain's accidental case appears to be the most satisfactory.

These considerations are mentioned in order to draw attention to the limited amount of reliable information available concerning the incubation period of *P. falciparum*. Factors such as the use of wild mosquitoes, experimenting among an already infected population, and the administration of quinine after the infective bite reduce materially the value to be attached to the figures. A further point to be mentioned, which may seriously affect the parasitic incubation periods given above, is that, as noticed previously, parasites are frequently present in relapse cases before a temperature reaction occurs. The importance of remembering this fact is seen when we consider Tables I, II and III. It will be noted that in these experiments, fourteen in number, parasites were always discovered either after the day of fever or on the day of fever, with the exception of one case (di Mattei), in which they were found 'a few days after injection.'

From what has been said, therefore, it is seen that the incubation period of malignant tertian malaria is a subject which would repay

further study. At present the evidence points to a minimum incubation, for inoculation of two days, and for mosquito bites of ten days. In view of the absence of evidence of inoculation infection in this case, we must suppose that an anopheline was the means of infection. There appears to be no sufficient evidence to exclude the possibility of a more brief incubation than ten days, the more so when we consider that a formerly accepted minimum incubation period of ten days for blood inoculation has given place to a later minimum incubation period of two days.

III. AT WHAT TIME AND WHERE DID THE CASE BECOME INFECTED?

It has been necessary to deal with a portion of this question above in discussing incubation periods, but there are other facts which may be employed to throw light on the subject.

Some assistance may be obtained from a study of the crescents and sporulating forms. Thomson (1911) states that, as a general rule, crescents appear in the peripheral blood on the fifth day after the attack of fever.

Marchiafava and Bignami (1894) found crescents in the finger blood of thirteen primary cases, usually between the seventh and eighth day of the disease, rarely as soon as on the fifth. Bignami and Bastianelli, who examined cases by spleen puncture, found crescents in the spleen as early as the seventh and eighth day, and exceptionally also in the peripheral blood.

It is seen from these observations that the spleen did not contain crescents any earlier than the peripheral blood. This corresponds with the findings in the present case, because an examination of smears of peripheral blood, spleen and bone marrow showed that whereas crescents were scanty in both peripheral blood and spleen, they were very numerous in the bone marrow. From this fact alone it could be deduced that death had occurred too early for crescents to be liberated from the bone marrow in large numbers. It has been shown by Marchiafava and Bignami (1894) that in certain cases of fatal malignant malaria, crescents may be scanty in the peripheral blood, spleen, and other viscera, while a very large preponderance of them is found in the bone marrow, where they may be seen in all stages. They conclude that the bone marrow

forms, if not the only, at least the most suitable site for the growth of crescents. They compare the passage of crescents from the bone marrow, where they are formed, with the corresponding passage of nucleated red cells from the bone marrow where they also are usually generated, into the general circulation.

Dudgeon and Clarke (1918-19) did not find crescents in their cases; they state in general of their fifty-one cases that no histological changes worthy of special reference were noted in the thyroid, bone marrow, testicles and pituitary body. They cite a very acute case of the haemorrhagic type, but no special mention of the condition of the bone marrow is made; it is a significant fact, however, that this case died in three days.

Applying the crescent periods and incubation periods to the present case we have a sequence, tracing back from the day of death, as follows:—October 12th, day of death, crescents present in small numbers in blood; allowing five days for crescents to appear in peripheral blood after paroxysm gives October 8th as day on which in a normal case the paroxysm should have occurred; allowing four days before this as the time when sporulating parasites first appeared in the peripheral blood, brings us to October 4th. From September 27th to October 4th is left for *parasitic* incubation period on the theory that she became infected by mosquito bite in the health resort in which it is known she was exposed to anophelines. This *parasitic* incubation period (seven days) is, even on the figures derived from the available experimental evidence, a probable one, and the history of the case supports it. It should be recalled that in this patient no shivering or sweating occurred and that we are dealing with a case of poor physique and considered to have been anaemic, the effect of which conditions upon incubation and reaction may be highly important, although by no means sufficiently recognised. Incubation will necessarily vary with the rapidity of the cycle of development of the parasite, the special reproductive energy of the particular parasite involved and the capacity of the infected human organism to facilitate or impede such parasitic reproduction.

In the light of our present knowledge of incubation periods, the occurrence of a mosquito infection six years ago or an inoculation infection eight months ago seems improbable, and we have further

no evidence at present to warrant us in regarding the case as one of endemic malaria. We are, therefore, compelled to decide whether she was infected at Liverpool or in the resort referred to. The evidence appears to me to support the last named as the place of infection.

THE SIGNIFICANCE OF CRESCENTS

Thomson (1911) considers the development of immunity to be necessary before crescents can be produced, but he thinks that they arise from ordinary merozoites, the period required for full development from merozoites to crescents being about ten days. He found, in common with previous observers, that crescents appeared in the blood about five days or more after the paroxysm, but while accepting the existence of a condition of immunity as essential to their production, he does not attribute their delayed appearance to the lapse of time required before immunity is established but simply to the length of time required for their development. The idea that the delay was due to the time required for immunity to establish itself had been put forward by Marchiafava and Bignami (1894) partly and also by Stephens and Christophers (1908). From a study of the appearances in this case, it is clear that the crescent-producing process was more advanced in the bone marrow than in the spleen or blood, and if the crescent-producing process is an 'immunizing' one, we may safely assume that its effect was first felt by the parasites in the bone marrow. Some evidence which might support the view that the process is connected with immunization may be obtained from a comparison of the relative numbers of crescents and segmenting forms present in the peripheral blood, spleen and bone marrow, respectively. In the peripheral blood the number of crescents and segmenting forms was about equal, in the spleen the segmenting forms far exceeded the crescents (fifteen to one), while in the bone marrow the segmenting forms were far outnumbered by the crescents (one to ten). Unless we assume that segmentation occurs at different hours in the bone marrow and spleen, or that red corpuscles containing young trophozoites cannot enter the bone marrow, on neither of which points is there any evidence, we are compelled to conclude that some agency in the bone marrow which causes the production of crescents

also prevents the completion of segmentation; that is to say, the bone marrow is the seat of a process which hinders the asexual while it facilitates the sexual development.

The number of crescents produced in any area such as the bone marrow which contains only a proportion of the total blood must be so small relatively to the areas where segmentation is occurring freely, that it seems evident that a certain time must elapse before the crescents reach the visibility point in the peripheral blood. This, in my opinion, is the real cause of the delay in their appearance, not only in primary cases but in relapses, and the delay seems bound to occur, even supposing that the 'immunizing' process already exists or becomes operative immediately in the bone marrow or other organs. It appears that this delay must occur, and that it is not necessary to attribute it to a growth period of the parasite, of the duration of which growth period this very delay is the only evidence. In this case the 'immunizing' process had commenced in the bone marrow, but there was no evidence, as indicated by great crescent production, that it had commenced in the other tissues available for examination. It is possible that in other cases it may occur early in other organs also.

NATURE OF THE 'IMMUNIZING' PROCESS WHICH RESULTS IN THE PRODUCTION OF CRESCENTS

Nothing definite can be deduced as to what this process is or what are the factors which call it into operation. But that it is in many cases quickly operative in the bone marrow is obvious, not only from this case but also from the observations mentioned above of the early appearance of crescents in bone marrow. It is also clear that many primary cases in which this process is already established in the bone marrow, nevertheless die, which supports the view that if the process is an 'immunizing' process it is focal in origin.

That the process is initiated by the mere presence of, or rupture of, segmenting forms, or by the toxins or pigment liberated at sporulation, is unlikely, in view of the observation in this case that in the spleen, where the most numerous segmenting forms occurred, crescents were scanty.

SUMMARY

1. A patient who had never been out of the British Isles died of malignant tertian malaria in Liverpool on October 12th, 1920.

2. There is evidence that this was an acute primary attack.

3. There is no evidence to show that this case acquired infection by other means than mosquito bite.

4. From a consideration of the records of incubation period and crescent formation, it is probable that the infection was acquired on or about September 27th, on which occasion she was in a northern health resort where anophelines are plentiful (*A. maculipennis*, *A. bifurcatus* and *A. plumbeus*).

5. Some evidence is given that crescent formation commences in the bone marrow, and that it is accompanied there by a failure of complete development in the asexual forms.

6. The 'immunizing' process which causes the above effects in all probability commences in some cases very early in the infection, but the crescents indicative of this process do not appear in the peripheral blood for some time.

7. The late appearance of crescents in the peripheral blood in infection with *P. falciparum* is explained on the ground that the source from which they arise is limited in extent.

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OBSERVATIONS ON MOSQUITOES IN THE ISLE OF MAN

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PLATES X—XIV

In recent years much interest has been shown in the mosquitoes of the British Isles, and many new observations have been made which increase our knowledge of the species which occur here. Twenty-two species, including three members of the genus *Anopheles*, have now been recorded from the United Kingdom, and many of them are also known to occur in Ireland; but, so far as we are aware, no information concerning the mosquitoes of the Isle of Man is available. Having recently had occasion to visit the Island, we took the opportunity of investigating the occurrence and distribution of mosquitoes. As, however, our visit extended over only a portion of November and December, it was impossible to make any detailed investigation of even those mosquitoes of which the over-wintering stages are known and readily found. Our activities were for the most part confined to localities easily accessible by railway or tramway, and were, therefore, mainly limited to the coastal region. The places visited and the records obtained are shown in the appendix and map.

GENERAL CONSIDERATIONS

I. Anopheline Mosquitoes.

A. bifurcatus, L. The larvae of this species were abundant and widely distributed over the Island, and were found without difficulty in spite of the fact that residual breeding-places only could be discovered at this time of the year. As is sometimes the case with mosquitoes of this kind, larvae were found in certain of the breeding-places only after considerable searching; this was especially noticeable in the more extensive breeding-places, such as the marsh-

land (Photo. No. 1) in the neighbourhood of Ballaugh and Sulby. On the other hand, relatively large numbers were sometimes obtained in a short time in the more circumscribed waters, such as the artificial pond at Groudle Glen (Photo. No. 2) and in the ditch at Castletown (Photo. No. 3). In the latter case, in the small ditch shown on the right of the photograph, over sixty larvae were captured in ten minutes by one person using a small scoop. As will be seen in the photographs, breeding-places of *A. bifurcatus* were found in various types of country, even close to the sea (Photo. No. 4); they occurred also in situations where free water was only discovered by close inspection and was chiefly limited to hoof prints, etc. (Photo. No. 5). They were also found in the near neighbourhood of towns, as shown in Photo. No. 6 (Appendix, No. 15).

A. maculipennis, Mg. Hibernating females of this mosquito were not found in such large numbers as (in view of the numerous potential breeding-places observed) we expected. All types of cow-sheds, stables, and other out-buildings from those of modern construction—high-roofed, well-lighted and well-ventilated —to those of primitive form—small, dark and badly ventilated— were systematically examined; it was naturally impossible, however, to obtain access to houses, and, therefore, it is not possible to give records relating to them. In only one case (Appendix, No. 21, Photo. No. 7) was any considerable number of females found, when one hundred and forty-seven were captured, this representing the great majority of those present in the building. In accounting for the relatively small numbers seen, the following two facts, which came under our notice, are possibly of some importance:—

1. Cleaning and lime-washing. In several instances we were informed that a thorough sweeping of the walls and roof to remove cobwebs had recently been carried out; this procedure in some cases had been followed by lime-washing.

2. Accidental cleaning of the roofs. Having observed in some cowsheds and stables with low flat roofs that cobwebs existed only in the corners, or over the manger, we made enquiries as to the reason of this. It is to be attributed to the practice of carrying on a fork the hay used as fodder, thus repeatedly brushing the greater portion of the roof.

Photograph No. 1

Photograph No. 2

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A. plumbeus, Steph. Although the Isle of Man is by no means heavily wooded, we experienced little difficulty in discovering the larvae of *A. plumbeus* on numerous occasions. The breeding-places were similar in nature to those of which we have given illustrations in our previous papers (1920). We found here a surprising difference in the tendency of the Spanish chestnut (*Castanea sativa*) to form rot-holes, and although no systematic survey was carried out, yet of nineteen breeding-places discovered, four occurred in this species of tree; whereas in Liverpool and district, of sixteen breeding-places found, none were present in the Spanish chestnut. Photo. No. 8 displays the most interesting breeding-place of this mosquito that we have yet discovered; a full description of it is given on p. 87 (No. 34). Interesting breeding-places were also found immediately adjacent to an out-door latrine (Photo. No. 9) at a country farmstead, and near the centre of a town as in Photo No. 10 (Appendix, No. 31 f).

It is necessary to note here that in no instance were the larvae of *Ochlerotatus geniculatus*, Ol., discovered. So far as our investigations have gone, although we have commonly found this species in the United Kingdom in association with *A. plumbeus*, we have entirely failed to find it either in Ireland or the Isle of Man, although *A. plumbeus* is abundant in both places.

II. Culicine Mosquitoes.

Culex pipiens, L. Females of this species were found in several of the localities in which buildings were visited. They were frequently found associated with *A. maculipennis* in occupied cow-sheds, stables and piggeries, but were distinctly more numerous in cooler stituations, *i.e.*, cellars, lofts, out-houses, etc. (Appendix, p. 88).

Theobaldia annulata, Schr. Larvae, pupae and adults of this mosquito were discovered in various places. The adults were relatively uncommon, but females were occasionally found in buildings, and, on one occasion (November 18th), both sexes were emerging from pupae contained in a wooden tub. This was standing in the back garden of a cottage at the Nunnery Mill, Douglas; the position of the tub in relation to the cottage is seen in Photo No. 11. The dimensions of the tub were 18 inches in top

diameter and 12 inches in depth; it was nearly full of rain water, which, on being stirred, produced a very evil odour due to a mass of putrifying leaves lying on the bottom; no larvae were found. Eighty-four pupae were collected from the tub, and from seventy-eight of these, twenty-seven males and fifty-one females emerged. Pupae of *T. annulata* were also found at Ramsey on November 22nd, in a marshy meadow situated behind the town (Photo. No. 6). Larvae of the second, third and fourth instars were abundant, and occurred in several different types of breeding-place (Appendix, p. 88).

Culicella morsitans, Theo. Larvae of various sizes were found; they sometimes occurred with the larvae of *T. annulata*, but were more definitely limited in regard to habitat. They were always found in open water containing abundant vegetation, and, in marshy land, appeared to favour more particularly the immediate neighbourhood of clumps of rushes (Appendix, p. 89).

Culicella fumipennis, Steph. Larvae of this species were found in one locality only, namely, in the extensive peat bog-land or 'curragh' in the vicinity of Ballaugh. They were, however, taken in two sites, but the nature of the breeding-places in regard to the types of vegetation present and colour of the water (reddish-brown) appeared identical. These larvae, some of which appeared but half-grown, were of a characteristic yellowish colour, and could immediately be distinguished from those of *C. morsitans*, which were darker and distinctly brown (Appendix, p. 89).

APPENDIX, GIVING RECORDS OF SPECIES OBTAINED, UNDER PLACE NAMES ARRANGED IN ALPHABETICAL ORDER

Anopheles bifurcatus, L.

(1) BALLAUGH, December 6th.

(*a*) The country immediately north of the railway to the East of Ballaugh Station presents features which are peculiar to this portion of the Island. It is a flat, desolate marshy country, with large expanses of water interrupted by collections of low bush and reeds. In Photo. 1, which gives a good idea of the appearance of much of this region, known as 'the Curragh,' the foreground represents an area adjoining the path, completely waterlogged and

Photograph No. 3

Photograph No. 4

Photograph No. 5

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communicating with the open water beyond. Larvae were found among the coarse grass seen in the foreground of the picture, but it was impossible to make any observations on the open waters.

Besides this breeding-place, two others were found of quite a different character.

(*b*) One was a pond in a field where the peat formation of the district was observed at the edges of the pond itself, and also in the brown discolouration of the water. Here larvae were obtained after breaking ice one-eighth inch thick.

(*c*) The other was near the railway line close to the station, and was a cutting for water, having a high bank, formed by the railway track, on one side. The water was clear and flowing, but in shallow areas at the margin, where grass, duckweed and watercress provided shelter, larvae were numerous.

(2) CASTLETOWN, November 30th.

(*a*) Near the public park, and separated from it by the river (Silver Burn), is a meadow with a stream running through it; this stream at the time of our visit was overflowing at various points, covering a large area with shallow, stagnant water. Only at one end of the flooded area, in a boggy patch, with hoofprints, was a single larva obtained after considerable searching, and none was found in the stream itself, which was moving fairly rapidly.

(*b*) In striking contrast to the absence of larvae from the centre of the meadow, was their abundance in a narrow ditch on the side remote from the river (Photo. 3).

In the photograph the ditch in question is on the right, while the flooded area extends to the left for a considerable distance outside the picture. In this ditch, which varied in width from 3 feet to about a foot in some parts, and which was a foot deep with overhanging banks, sixty larvae were collected in ten minutes by one person using a small scoop. The vegetation was chiefly grass and watercress, and from the abundance of life of various kinds present we were led to conclude that this formed a permanent and very suitable breeding-place for *A. bifurcatus*.

(3) DOUGLAS, November 18th.

In the neighbourhood of Douglas outside the Nunnery estate, about twenty minutes' walk from the quay, an extensive breeding-

ground is present. It is that portion of flat land which lies to the right of the path outside the Nunnery towards the racecourse. The only indication of the marshy nature of this ground was the appearance of reeds, as the water was concealed by the vegetation and was not visible even at a few yards distance.

The area is approximately 120 yards by 35 yards, and is continuous with a similar area not examined by us on the left of the path, where it turns towards the racecourse. In the area under consideration larvae were constantly found on testing in various directions at five-yard intervals, very frequently in hoofmarks. Beyond this field, across the hedge towards the racecourse, is what appeared at first sight to be a continuation of the same sort of half marshy ground, but the water present was red and contained a great quantity of flocculent material. No larvae were found here despite prolonged testing.

(4) Glen Garwick Road, November 19th.

No larvae were found actually in this glen, although a swampy patch just in front of the hotel was regarded as promising, but a breeding-place occurs beside the Electric Tramway line from Groudle, just beyond the level crossing past Liverpool Arms Hotel to the left of the line going towards Garwick. Larvae were found here in a field which was marshy, and their distribution appeared to coincide with the occurrence of patches of duckweed.

(5) Glen Greenaugh, December 1st.

In a pond on the property of Balla Vale, just above the weir across the stream, larvae were found in small numbers. The pond contained a large quantity of dead leaves, and at one end where larvae were found grass was present; it is situated about 150 yards from the house.

(6) Glen Groudle, October 28th and November 16th.

(*a*) On the occasion of the preliminary visit, a large breeding-place was found in the glen in the shape of an artificial pond which lies between the path and the river, and which is used as a fernery. The breeding-place is 80 yards long by 25 yards across at its widest part, and is situated about 500 yards from the viaduct. The pond is sub-divided into what is practically a series of small ponds by

Photograph No. 6

Photograph No. 7

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means of banks of considerable width. Larvae were found with ease all over the area. The vegetation consists of coarse grass, reeds, waterlilies and, on the banks, ferns (Photo. 2).

(*b*) On the second visit, by passing down the glen, we found a breeding-place at Groudle Creek in close proximity to the sea, separated from it, in fact, only by a bank of shingle and the banks of the river itself; it is seen in Photo. No. 4.

From its proximity to the sea and from the presence of much seaweed and flotsam in this collection of water, we concluded that it must contain a considerable excess of sodium chloride, and the water had a brackish flavour; but analysis* showed that, in fact, it contained only 7·63 parts per 100,000, which is stated to be lower than many potable waters of the Isle of Man.

This breeding-place, which was about 30 yards from the sea and 100 yards from the nearest croft, did not yield numerous larvae.

(7) GLEN LAXEY, November 20th.

Close to the entrance to Laxey Glen Gardens there is a boggy-looking field on the left of the path, in which larvae were found. The field is bordered by a wall (seen in Photo. 5), which separates it from the bandstand and pleasure ground. To the right of the position seen in this photograph are various swings and apparatus for the amusement of the numerous children visitors. The hotel lies behind the camera to the right at a distance of about a hundred yards.

It may be noted again here that even at a short distance the presence of water could not be perceived, but could only be inferred from the character of the vegetation.

(8) GLEN SULBY, December 7th.

The Curragh region mentioned above in connection with Ballaugh extends towards Sulby Glen, and can be approached from this point.

(*a*) At the edge of the Curragh larvae were found in a field surrounded by stagnant ditches. The centre of the field was swampy and larvae were found here, and, where the water was clear among the reeds, in one of the ditches bordering the field; in two

* Kindly carried out for us by Mr. Fyffe of the Public Analysts Laboratory, Douglas, Isle of Man.

other ditches, where the water was loaded with red flocculent material, no larvae were discovered.

(*b*) Another breeding-place was found in Sulby itself, about 400 yards from the Glen Hotel. It was a marshy piece of ground beside the road, and was bordered on the far side by an area of higher ground where many trees had recently been cut down. The photograph showing this breeding-place of *A. bifurcatus* shows also a very uncommon breeding-place of *A. plumbeus*, and will be found under the latter heading, Photo. 8.

(9) GLEN WILLYN, December 7th.

In the terminal part of this glen, about 300 yards from the sea, there are pleasure grounds furnished with bandstand, swings, etc. These abut on the small stream, and just opposite them is a narrow wet strip of ground at the foot of a steep hill. In this wet area larvae were found in that portion adjacent to the fence which runs along the side of the stream, and separated from the pleasure ground by only the width of the stream.

(10) GREEBA, December 5th.

The railway from Douglas to Peel runs in a valley for a considerable portion of the way. The land close to the railway is marshy, and has at intervals much free water lying on it. This strip of wet land was examined in the region of Greeba, and there was no difficulty in finding larvae.

(11) PEEL, December 8th.

Larvae were found in a small narrow drain at the foot of the hill bordering the road along the quay on the way to Peel Castle. The water was sluggish and much grass was present in many places.

(12) PORT ERIN, November 26th.

Three breeding-places were discovered in this locality.

(*a*) The first was in marshy ground in the valley near the far end of the golf course.

(*b*) The second was a slow-moving stream with high banks and much vegetation, chiefly grass and watercress situated between Port Erin and Ballafesson village.

(*c*) The third was a small piece of marsh land covered with reeds in the centre of the village of Ballafesson.

Photograph No. 8

Photograph No. 9

C. Tinling & Co., Ltd., Imp.

(13) PORT SODERICK, December 5th.

About half a mile before Port Soderick, on the road from Douglas, beside the road a breeding-place was found. It consisted of a pool of clear water, deep in the centre with a rapid streamlet running through it. The vegetation was considerable, and consisted of a fairly thick layer of duckweed which covered the centre of the pool and reached to within a few inches of the edge in most places. The edges were covered with grass and duckweed. The larvae were present in numbers, and were found chiefly near the edges.

(14) PORT ST. MARY, November 29th.

Close to the station, in a meadow belonging to Ballacreggan Farm, just behind the gas works, a small ditch a foot wide, overgrown with grass and not conspicuous, proved to contain larvae. The water was clear and had a few patches of duckweed on it at intervals, and the surface of the water was about a foot below the level of the banks, which were undermined.

(15) RAMSEY, November 22nd.

An excellent breeding-place was encountered on the outskirts of the town. The extent of this area, a marshy field, is 120 by 120 yards, approximately. Very numerous larvae were found here. Situated about 15 yards away is the playground of a large school, which can be seen in Photo. No. 6. In the whole of this area larvae were found.

(16) ST. JOHN'S, December 8th and 9th.

(*a*) Larvae were found in a pool in a field adjacent to the station. This pool serves partly as a cesspool for drainage from the station lavatories; it is situated 10 yards from the platform, 6 yards from the lavatories and about 30 yards from the main road. The water was slightly coloured, the margins very boggy, and the vegetation mostly rushes with some duckweed and grass.

(*b*) On the road from St. John's to Peel, in a field on the right side of the road about half a mile out of St. John's, larvae were found in the margins of a narrow, rapid stream at the foot of a hill.

(*c*) Further on the road, about a quarter of a mile beyond this breeding-place, a considerable amount of marshy ground exists at

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(*c*) Further on the road, about a quarter of a mile beyond this breeding-place, a considerable amount of marshy ground exists at

the side of the railway. There is an extensive breeding-place between the railway and the St. John's-Knockaloe Road, the edge of the marshy ground lying 100 yards distant from the nearest farmstead.

Anopheles maculipennis, Mg.

A number of cowsheds, stables, piggeries, fowl-houses, latrines, outhouses, cellars, lofts, sheds and shelters of various kinds were examined with a view to finding the adults of this mosquito.

(17) BALLAUGH, December 6th.

(*a*) Three cowsheds were examined, of which two were small, dark, warm, flat-roofed, with numerous cobwebs present, and the third lofty, well-lighted, with gable roof and almost free from cobwebs. In one of the former, three, and in the last, one *A. maculipennis* ♀ were captured. Total 4 ♀

(*b*) One stable of modern construction, with high gable roof, but rather dark ... ... 2 ♀

(18) CASTLETOWN, November 30th.

(*a*) One cowshed, small, dark, warm, low-roofed, situated in the centre of the town ... ... 10 ♀

(*b*) One stable for two horses, in centre of town, low-roofed and warm, with few cobwebs except in one corner ... 3 ♀

(*c*) One outhouse adjoining stable, and of same construction, used as a potato store, cooler and draughty ... ... nil.

(*d*) Two lofts; one warm, dark, slate-roofed, with few cobwebs, situated over (*b*) and (*c*), nil; the other situated above (*a*), dark, slate roof, numerous cobwebs, 1 ♀. Total 1 ♀

(19) DOUGLAS, November 18th.

At the Nunnery Mill the following were examined:—

(*a*) Stable, a large, dark stable on ground floor, just being whitewashed, few cobwebs ... ... nil.

(*b*) Fowl-house, low and dark ... ... nil.

(*c*) Cellars extensive, low-roofed, under mill house ... nil.

(*d*) Loft situated above (*a*), but not newly whitewashed, cobwebs numerous ... ... nil.

(*e*) One stone-built shelter, used as a fowl run ... ... nil.

Photograph No. 10

Photograph No. 11

C. Tinling & Co., Ltd., Imp.

At the back of the town:—

(*a*) Stable, small, dark, flat-roofed, warm, numerous large cobwebs ... ... nil.

(*b*) Outhouse adjoining, lighter and cooler ... ... nil.

(*c*) Loft above (*a*) and (*b*), dark, warm, wood-roofed ... nil.

(20) GLEN GARWICK ROAD, November 19th.

(*a*) One stable, disused ... ... nil.

(*b*) One loft, above (*a*) ... ... nil.

(21) GLEN GROUDLE, October 30th, November 15th and 16th.

(*a*) One cowshed, situated 15 yards from a cottage (Photo. 7) and 100 yards from a breeding-place of *A. bifurcatus* was examined. It was gable-roofed but dark, low, warm and had many cobwebs. The door was central in the side wall, and at one end two cows were kept, the other end being a coal and wood store. There were captured here, distributed equally over both ends of the shed, but less numerous just at the door ... ... 147 ♀

(*b*) One stable for two horses, dark, flat-roofed, moderately warm, but draughty... ... ... 22 ♀

(*c*) Three latrines near stable ... ... nil.

(*d*) Four cellars situated near stable, two in house and two under verandah ... ... nil.

(*e*) Three outhouses ... ... nil.

(*f*) One loft over (*b*), communicating with the stable by an opening two feet square above the manger, and by ladder entrance also, well-lighted, clean and airy, recently renovated roof of corrugated iron, few cobwebs, draughty ... ... nil.

(*g*) Two sheds, corrugated iron, a few yards from stable, containing piles of wood ... ... nil.

(*h*) One shelter (public) in glen ... ... nil.

(*i*) One kennel ... ... nil.

(22) GLEN SULBY, December 7th.

Two cowsheds:—

(*a*) One very small, two animals, gabled, corrugated iron roof, dark, warm, the roof moist, cobwebs very numerous ... 9 ♀

(*b*) Similar but wood-roofed, recently swept, few cobwebs nil.

(23) KIRKMICHAEL, December 7th.

(*a*) Three cowsheds, flat-roofed wood, dark, warm, clean, to hold twenty, eight, four animals, respectively ... ... nil.

(*b*) One pigstye, usual type, dark, fairly warm, cobwebs numerous ... ... nil.

(*c*) One loft above largest cowshed, high gable roof, dark, warm, many cobwebs ... ... nil.

(24) PEEL TO ST. JOHN'S, December 8th.

(*a*) Two cowsheds:—

(i) Large, sixteen animals, flat-roofed, warm, cobwebs over mangers and in corners only ... ... 4 ♀

(ii) Large, ten animals, flat-roofed, dark, few cobwebs, except in corners ... ... 17 ♀

(*b*) Two stables:—

(i) Flat wood roof, warm, dark, few cobwebs ... 2 ♀

(ii) Similar but more cobwebs ... ... nil.

(*c*) One latrine outside house ... ... nil.

(*d*) One loft above (*a*) (ii); high gable roof, cool and airy, containing straw and hay ... ... nil.

(25) PORT ERIN, November 26th and 29th.

(*a*) Four cowsheds:—

(i) Two, low flat wood roof, dark, warm ... ... nil.

(ii) Two, iron roof, low, warm, moist, dark ... nil.

(*b*) Three stables, dark, unventilated, cooler than cowsheds. In one ... ... 1 ♀

(*c*) One pigsty, low, dark, wood roof, many cobwebs ... nil.

(*d*) Two fowl-houses, thatched low ... ... nil.

(*e*) One loft above (*a*) (i), dark, cool ... ... nil.

(26) PORT ST. MARY, November 29th.

(*a*) Two cowsheds, large, dark, gable, slate roof recently limewashed, few cobwebs ... ... nil.

(*b*) One outhouse, continuation of cowshed, cold, draughty nil.

(*c*) Two sheds, one for straw, one for carts ... ... nil.

(27) RAMSEY, November 22nd, 23rd and 24th.

(*a*) Four cowsheds:—

(i) One for six animals, low wood roof, dark, warm ... ... 1 ♀

(ii) Three, first rather light, cool, corrugated iron roof; second and third warm, low wood roof, dark; in third ... ... 3 ♀

(*b*) Four stables:—

(i) One large, airy, high corrugated iron roof, few cobwebs, accommodation for about fifty horses ... 1 ♀

(ii) Two, small, wood roof, dark, with cobwebs... nil.

(iii) One, airy, light, cool, wood roof, cobwebs numerous ... ... nil.

(*c*) Six pigsties; usual type, in each of two, one female.

Total ... 2 ♀

Anopheles plumbeus, Steph.

(29) BALLASALLA, December 9th.

Sycamore. A breeding-place was found just outside the churchyard of the Abbey Church, between it and the river. The tree was situated a few yards from the road. The aperture was at a height of 5 feet from the ground and 1½ inches in diameter, depth of hole 6 inches; the water was yellow tinged.

(30) BALLAUGH, December 6th.

Sycamore. In the farmstead of Mr. Kneen a breeding-place of this mosquito was found in a tree situated about 30 yards from the dwelling-house. The aperture, situated 8 feet from the ground, was 6 inches in diameter and the depth of the cavity 12 inches. Small larvae only were found.

(31) DOUGLAS, October 30th, November 18th, December 3rd.

Seven breeding-places were found in and near Douglas. On the previous visit, October 30th, two breeding-places, (*a*) (*b*), were found in the small glen behind Falcon Cliff Hotel.

October 30th:—

(*a*) *Sycamore*, situated 15 yards from the garage and 27 yards from the main road. Aperture at 1½ feet from the ground, diameter

about 6 inches, depth 9 inches. The whole trunk was hollow. Large and small larvae numerous.

(*b*) *Sycamore*, 60 yards from garage and 10 and 12 yards, respectively, from two roads. Aperture 1 foot from ground, hole 9 inches deep; small larvae.

November 18th :—

(*c*) *Sycamore* in garden of Nunnery Mill Cottage, situated 12 yards from house. Aperture 12 feet from ground, measuring 2 by $1\frac{1}{2}$ inches, numerous larvae.

(*d*) *Lime* in paddock below cottage and mill. Situated 30 yards from house and 15 yards from the mill.

(*e*) *Sycamore* just outside garden of Mill Cottage. Aperture about 4 feet from ground, with a smaller aperture 3 feet from the ground almost level with the water. Owing to difficulties in either siphoning or scooping out the water in this cavity, resort was had to flushing out the larvae by pouring a bucket of water into the upper opening and catching the water as it emerged from the lower opening.

December 3rd :—

(*f*) *Sycamore* situated in garden of Marina Terrace, at the junction of two streets and distant 20 yards from an elementary school (Photo. No. 10). Aperture at 2 feet from ground 5 by 3 inches in size and cavity 6 inches deep.

(*g*) *Sycamore* in same garden 5 yards from the previous one. Aperture 2 feet from ground 8 by 5 inches, depth 2 feet; small larvae numerous.

(32) GLEN GROUDLE, November 19th.

Spanish Chestnut. Just where the bridge on the high road crosses the Groudle river, a very large breeding-place was found. The aperture, which is at 10 feet from the ground, appears over the parapet of the bridge and is 9 inches in diameter, the cavity being full of red water to within 2 inches of the lip of the aperture.

(33) LAXEY, November 20th.

Spanish Chestnut. In Laxey Glen Gardens, on the right side of the arena in front of the bandstand, are some trees on a slightly raised terrace; in one of these, larvae were found; aperture at $6\frac{1}{2}$ feet

from the ground, 3 inches in diameter and facing upwards, depth of cavity 15 inches.

(34) GLEN SULBY, December 7th.

Ash. Breeding-place found in this locality is of exceptional interest. In an area situated 400 yards from the Glen Hotel, where many trees had recently been cut down, larvae were found in the stump of an ash tree. The aperture is a foot in diameter, but before water is reached at 18 inches from the top of the stump the cavity has widened greatly, so that the surface of the water is very much larger than the aperture of entrance. Not only so, but also the cavity extends downwards until it is much below the level of the ground. That the breeding-place is a true rot-hole, and entirely contained in the tree stump, is shown by the facts that it was impossible to push a stick down through it at any place, and that the water was deep red in colour; it contained numerous larvae of *Myiatropa florea* and various chironomids (Photo. No. 8). This photograph is further of interest because the marshy ground below, indicated by arrow, is a breeding-place of *A. bifurcatus*.

(35) KIRK BRADDAN, December 10th.

Sycamore. Near Braddan Church, a tree was found with a cavity containing larvae. It stood on a bank behind the Hotel at a distance of 20 yards. Two apertures were present about 4 feet from the ground and about 5 inches in diameter.

(36) KIRK MICHAEL, December 7th.

Spanish Chestnut. The breeding-place found here was in a tree situated in a field to the right of the road leading to a farm (Mr. Mylchreest), and distant 12 yards from the cowsheds and 80 yards from the White House. The aperture was at a height of 7 feet and was remarkably small, about 1 inch. By means of the siphon, however, a great rush of red water was obtained from a large cavity, with larvae in numbers.

(37) PEEL, December 8th.

Spanish Chestnut. The nearest point at which *A. plumbeus* was found was the estate of Ballamore. The tree was situated beside the main road. The aperture was 9 feet from the ground and 8 inches in diameter, depth 6 inches.

(38) RAMSEY, November 23rd.

On the estate of Miltown, outside Ramsey, two breeding-places were found.

(*a*) *Sycamore*, situated 15 yards to left side of Ramsey Road. Aperture at 10 feet from ground 6 by 7 inches, depth 2 feet, the water surface being about 1 foot from lip of aperture; numerous larvae

(*b*) *Sycamore*. In close proximity to the foregoing, aperture at 8 feet from ground, 12 inches in diameter, a very large cavity full of a pulpy mass of débris, with a layer of water on the top.

(39) ST. JOHN'S, December 8th.

At a house on the St. John-Knockaloe Road, just beyond Ballamore estate on the left of the road, two breeding-places in sycamores were found.

(*a*) *Sycamore*. This was situated 20 yards from cowsheds and 30 yards from house; aperture at 4 feet from ground, 9 by 4 inches, depth 9 inches; trunk above hole also hollow for more than 18 inches up; numerous larvae, over twenty in the first scoopful of water taken out.

(*b*) *Sycamore*. Standing immediately beside a latrine, 15 yards from the house. There was a large cavity with two apertures, each about 5 to 6 inches in diameter (Photo. No. 9).

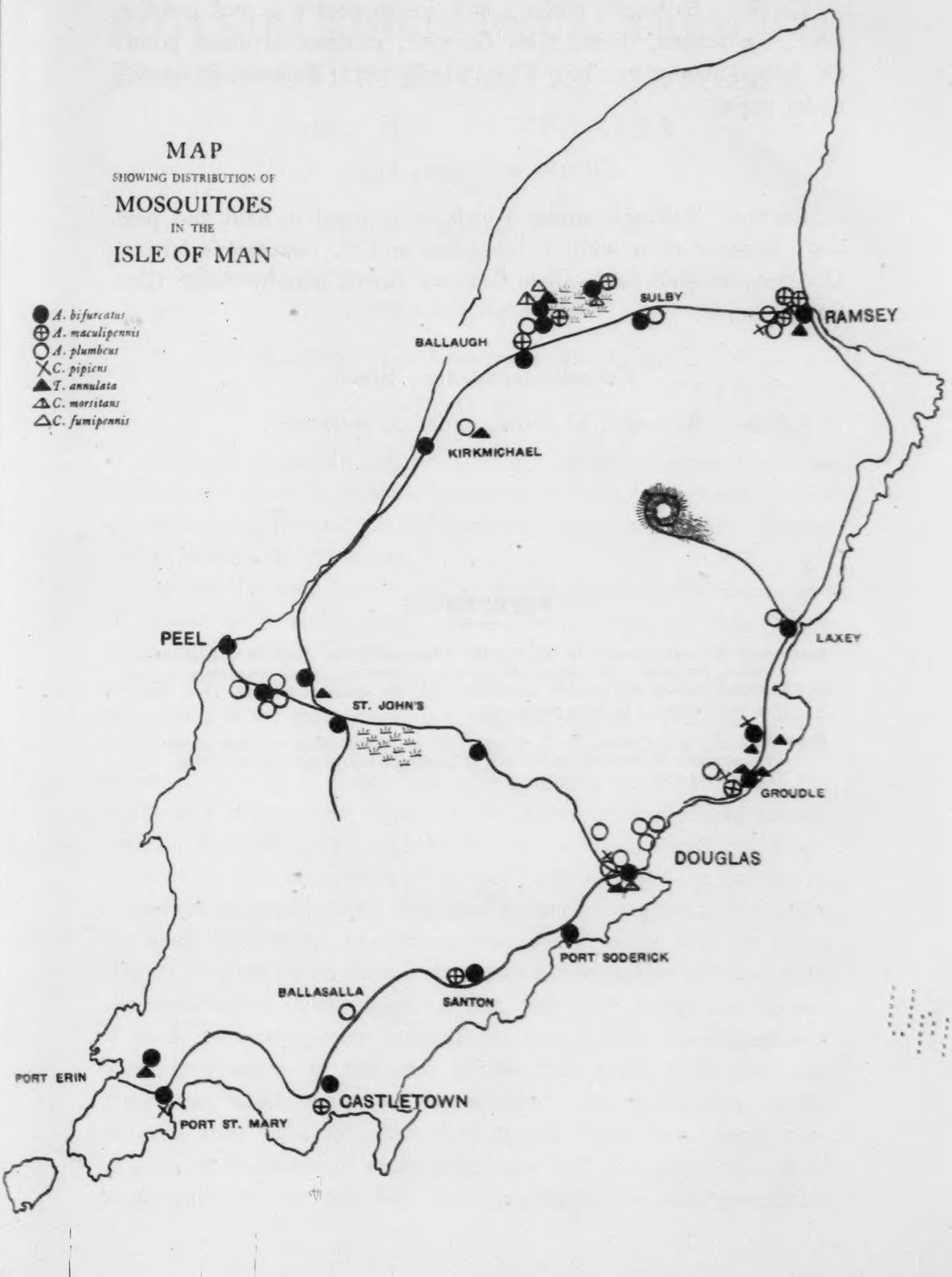
Culex pipiens, L.

Hibernating females were found in the following places:—Douglas, in 1 stable, 1 fowl-house, 1 cellar, 1 loft, 2 shelters, 1 latrine; Glen Garwick Road, 1 stable, 1 loft; Groudle Glen, 1 outhouse, 2 latrines, 2 cellars, 1 loft, 2 sheds; Port St. Mary, 1 shed; Ramsey, 3 cowsheds, 2 stables, 3 piggeries, 1 loft, 1 shed.

Theobaldia annulata, Schr.

Hibernating females were found:—Groudel Glen, 1 cellar, 1 loft, 1 latrine, 1 open shelter; Kirkmichael, 1 cowshed.

Pupae. Douglas, Nunnery Mill Cottage, in wooden tub (see photo. 11). Ramsey, in association with larvae of *A. bifurcatus* (Appendix, No. 15).


MAP
SHOWING DISTRIBUTION OF
MOSQUITOES
IN THE
ISLE OF MAN
A. bifurcatus
A. maculipennis
A. plumbeus
C. pipiens
T. annulata
C. morsitans
C. fumipennis
BALLAUGH
SULBY
RAMSEY
KIRKMICHAEL
PEEL
LAXEY
ST. JOHN'S
GROUDLE
DOUGLAS
PORT SODERICK
BALLASALLA
SANTON
PORT ERIN
CASTLETOWN
PORT ST. MARY

Larvae. Ballaugh, under $\frac{1}{8}$-inch ice in peat bog and pond in field; Castletown, ditch; Glen Garwick, concrete artificial pond; St. John's, manure pit; Port Erin, marshy field; Ramsey, see above, under pupae.

Culicella morsitans, Theo.

Larvae. Ballaugh, under $\frac{1}{8}$-inch ice in pond in field and peat bog, in association with *T. annulata* and *C. fumipennis* larvae; Douglas, marshy field; Glen Garwick Road, marshy field; Glen Sulby, marsh.

Culicella fumipennis, Steph.

Larvae. Ballaugh, as above, under *C. morsitans*.

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NOTES ON SOME UNUSUAL BREEDING-PLACES OF *STEGOMYIA FASCIATA*, FABR., IN AUSTRALIA

BY

G. F. HILL, F.E.S.

From the Australian Institute of Tropical Medicine, Townsville, Queensland

(*Received for publication* 1 *March*, 1921)

PLATE XV

Although generally regarded as a domestic species, there are several records of *S. fasciata* breeding in rot-holes in trees and in water-retaining plants; this habit, however, appears to have escaped notice hitherto in Australia.

On 20th January, numerous larvae and pupae of this species and of *Ochlerotatus notoscriptus*, Skuse, were collected from a tin containing about 5 inches of water and a quantity of decaying leaves, which was found in the dense scrub 600 yards distant from the nearest of several seaside dwellings on Magnetic Island. Several adult *Stegomyia* which were captured at the same time (1 p.m.) while attempting to bite, and others which were bred from the larvae and pupae, were noticed to be distinctly darker and smaller than the forms found throughout the year in the Institute buildings. In order to determine the permanency of this dark form, a number of these males and females were bred from for five generations under the usual laboratory conditions, and concurrently with an equal number of generations from individuals of the lighter coloured form commonly found in dwellings. From both series males and females of each generation were secured for comparison, the experiment being terminated, in the case of the dark form, with the sixth generation, which comprised males only. An examination of the material thus obtained showed that the light form bred true, *i.e.*, the individuals of each generation did not differ from their progenators, whilst the dark form produced, in each generation

after the first, a proportion of individuals of both forms, as well as intermediate forms. In both series some variation was noticed in the shape and width of the outer lyre-shaped thoracic ornamentation and in the length and width of the median thoracic stripes, but in none were the latter entirely absent, a character recorded by Taylor (1914).

The island referred to above lies in Cleveland Bay, about four miles distant from Townsville, and was formerly utilised as a site for the port Quarantine Station.

On 5th May, a considerable number of mosquito larvae were siphoned from a rot-hole in a poinciana tree (Plate XV), growing in the Hospital grounds and distant about 70 yards from the nearest dwelling. In addition to *Macleava tremula*, Theobald, and *Ochlerotatus quasirubrithorax*, Theobald,* this collection produced a large number of *Stegomyia fasciata*, similar in size and colouration to the Magnetic Island form. On 7th September, another batch of larvae and pupae were collected from this hole, and from them about one hundred adults were bred. In this case the males were of about the average size, but quite as dark as any I have seen, whilst the females were of the light form and unusually large.

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* Identified by Mr. F. W. Edwards, as a variety of this species.

ROT-HOLE IN POINCIANA TREE.
BREEDING PLACE OF *OCHLEROTATUS QUASIRUBRITHORAX*, *MACLEAYA TREMULA* AND *STEGOMYIA FASCIATA*

C. Tinling & Co., Ltd., Imp.

MUSCA DOMESTICA, LINN., AS A 'BUSH FLY' IN AUSTRALIA

BY

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(*Received for publication* 1 *March*, 1921)

In the literature dealing with the etiology of *M. domestica*, I can find no record of this species in the rôle of a 'bush fly,' *i.e.*, a fly which lives and breeds normally beyond the range of human habitations, although I understand that Major E. E. Austen is of opinion that this species originated in the tropics and has thence spread to temperate climates, where it is only able to maintain itself by the fact that it has taken to living in houses.

In two widely separated localities in North Australia, evidence has been gathered which strongly suggests in one case, and proves conclusively in the other, that this ubiquitous species is not dependent upon human habitations and environments for its existence.

During the period 1913-1917, specimens were frequently captured in the Darwin District (Northern Territory) on stock and carcasses at distances up to a couple of miles from dwellings, but for some time it was considered probable that these flies were bred under the usual conditions; later, however, examples were captured in company with *Musca ventrosa*, Wied. (*M. nigrithorax*, Stein.), and *M. humilis*, Wied. (*M. vetustissima*, Walk.) on the carcasses of freshly skinned buffaloes which had been shot in scrub country from three to six miles distant from the nearest habitation—a cattle station sixteen miles distant from the next nearest dwelling and about thirty miles from Darwin. During the summer months, *M. domestica* were very numerous at the station, especially in the kitchen and adjacent living room, but they were not seen on men or horses after leaving the homestead for the haunts of the buffaloes.

In April, 1919, an officer of the Stock Department, Townsville (N. Q.), brought in for identification a large number of flies which had been captured in the vicinity of a slaughter-yard and upon

stock grazing in the locality, in some cases more than a mile from the nearest dwelling. This and later collections invariably included a large proportion of *M. domestica*.

During the months of April to October, flies of the same species were frequently captured upon grazing horses and cattle, and upon my face, hands and clothing in the Town Common at distances up to two and a half miles from habitations. On these occasions they were generally associated with *M. lusoria*, Wied.[1] (*M. australis*, Macq.,[2] *M. fergusoni*, J. & B.[3]), and *M. nebulo*, F.[4], (*M. hilli*, J. & B.[5]), the last named being less aggressive than the others. From October to about the end of March, *M. humilis*, Wied.[6] (*M. vetustissima*, Walk.) is the predominant species, and is certainly the most widely distributed *Musca* found in Australia, being as plentiful in the outer suburbs of Melbourne (Victoria) as it is in Central Australia, N. Territory, and the N.W. and Kimberley Divisions of W. Australia.

In the bush or open grazing country near Townsville, *M. domestica* oviposits on fresh horse-droppings, but they will also oviposit and rear their progeny on decaying vegetable matter, as shown by the fact that upon two occasions I have bred adults from full-grown larvae taken in nests of the Black-throated Grebe (*Podicipes novae-hollandiae*), which had become stranded upon the margin of a swamp, and in which the eggs had not yet hatched. The same nests and, also, small accumulations of drift, *i.e.*, leaves, horse- and cow-droppings, etc., blown up upon the margins of swamp, served as breeding-places for *Stomoxys calcitrans* and *Sarcophaga* sp.

Major E. E. Austen, who kindly examined the specimens of *M. domestica* from bush localities in N. Territory and N. Q., determined the latter as a variety of the typical form. Evidently the distincion is a very fine one, since recently I have examined a much longer series than was available to that worker, and I have compared them and their larvae with typical forms (from town dwellings) and their progeny, without being able to detect any variations peculiar to one series.

(1), (4), (6) Identified by Professor M. Bezzi.
(2) Identified by Major E. E. Austen.
(3) Johnston, T. H. and Bancroft, M. J. *Proc. Roy. Soc. Queensland.* Vol. XXXI, No. 12.
(5) Johnston, T. H. and Bancroft, M. J. *Mem. Queensland Museum.* Vol. VII, pt. 1. 1920.

NEW TSETSE-FLIES (*GLOSSINA*) FROM THE BELGIAN CONGO

BY

PROFESSOR R. NEWSTEAD, F.R.S.

AND

MISS ALWEN M. EVANS, M.Sc.

(*Received for publication* 14 *March*, 1921)

We have just received from our esteemed colleague, Dr. J. Schwetz, a small collection of tsetse-flies, captured by him in the Belgian Congo. Included in this collection are eleven examples (6 ♂♂, 5 ♀♀) of a new and hitherto undescribed species, all of them taken in the region of the River Kwango, on the frontier of the Portuguese territory. In his letter, dated 20.xii.20, Dr. Schwetz says that he had just visited this region for the first time, and that in returning down the River Kwango by boat he came to a region abounding in this species and *Gl. palpalis*, R.D.

This new species belongs to the '*Fusca* Group'[1] of tsetse-flies, and is described below as *Glossina schwetzi*, sp. n., in honour of its discoverer, who has devoted long years of research into the bionomics of this important group of insects, and their relation to human trypanosomiasis.

In a former communication in these *Annals*[2] attention was called to a variety or race of *Glossina fusca*, Walker, from the Belgian Congo, in which the female armature exhibits a marked deviation from the form of signum found in typical examples from the Gold Coast. The male genital armature of the Congo examples also differ in the form of the harpes from those found elsewhere.

We are convinced, therefore, that we have to deal with a well-marked race of *Glossina fusca* : this we have given varietal rank under the name *congolensis*, var. n.

GLOSSINA SCHWETZI, sp. nov.

Hairs of the third antennal segment about one-sixth to one-seventh the width of the segment. Wings of the female with the thickened portion of the anterior transverse vein darker in colour than the rest. Harpes of the

male divided into three processes, the proximal process short and spine-like. Female with signum of the uterus consisting of a single chitinous plate, the long axis transverse and widest in the distal third.

MALE : Length, 10-11·9 mm. ; proboscis, 2·3-2·8 mm. ; width of head, 3·2-3·3 mm. ; front at vertex, 0·6-0·7 mm. ; wing, 11-12·4 mm.

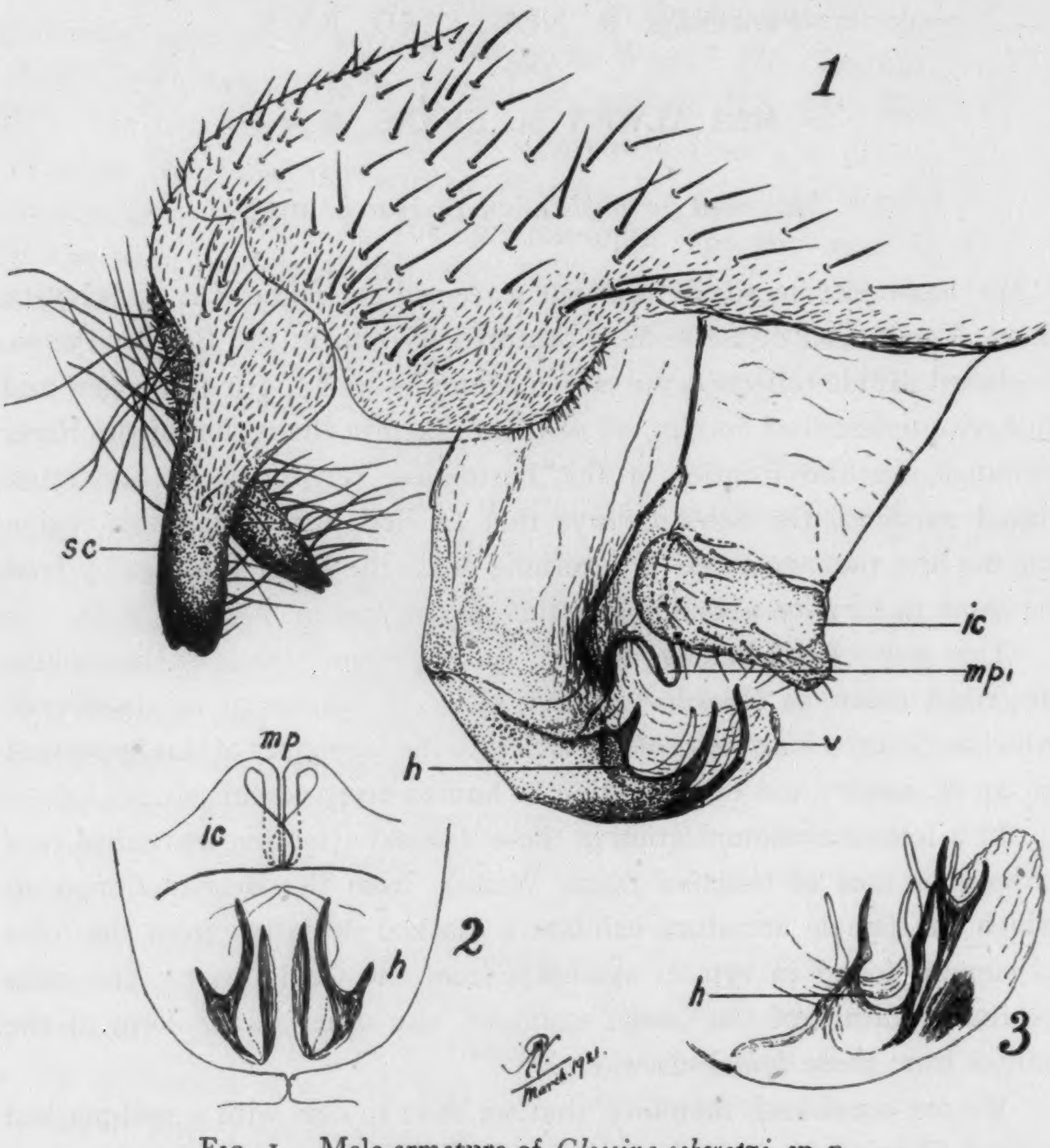

FIG. 1. Male armature of *Glossina schwetzi*, sp. n.

s.c., superior clasper ; *i.c.*, inferior clasper ; *m.p.*, median process ; *m.p.i.*, inferior median process ; *v.*, vesica ; *h.*, harpes.

FEMALE : Length, 12·5 mm. ; proboscis, 3·1 mm. ; width of head, 3·5-3·6 mm. ; front at vertex, 0·75-0·8 mm. ; wing, 13·2-13·6 mm.

MALE : *Head* with the posterior surface 'mouse grey' (Austen)[3], antennal cavity pearl-grey, sometimes with a pale vinous tinge ; ocellar

spot and frontal stripe unicolorous pale brown ; antennae with the distal two-thirds of the third segment infuscated, the rest pale buff ; outstanding hairs on third segment, short, about one-sixth to one-seventh the width of the segment. *Proboscis* bulb pale translucent buff-yellow, the upper lateral margins brownish or orange-brown, ventral median suture proximally, dusky to orange-brown. *Thorax* with the usual distinctive colour and markings ; sterno-pleurae more or less infuscated ; scutellar bristles long. *Abdomen :* Dorsum of first and second segments light brown ; the remaining segments, together with the lateral margins, dark brown ('mummy-brown,' Austen[3]), the distal angles either unicolorous with the rest of the abdomen or slightly paler. *Legs :* Light or dusky ochraceous-buff ; leg I with the femora infuscated on the upper half of the inner surface, tips of the last two segments dark brown or black ; leg II with the tips of the last two segments generally more strongly marked than in I ; leg III with the last two segments entirely dark brown or black, paler beneath, proximally. *Wings* with the thickened portion of the anterior transverse vein scarcely darker in colour than the rest. *Genital armature :* (fig 1) Harpes (*h*) with three bi-lateral processes ; the proximal process short and distinctly spine-like ; second and third pairs long, slender, and only very slightly widened proximally ; median process scarcely projecting beyond the inferior claspers (*ic*) ; the inferior median process (*mp₁*) narrowly elongated and projecting backwards considerably beyond the inferior claspers. Superior claspers (*s.c.*) bluntly bifid.

FEMALE : Colour and pattern similar to that of the male ; but the distal segment of the abdomen usually paler, and the thickened portion of the anterior transverse vein of the wing darker in colour than the rest. *Genital armature :* (fig. 2) External armature possessing no distinctive characters. Signum of the uterus consisting of a single symmetrical chitinous plate of the form shown in the figure, the greatest width being 0·38 mm. Laterally, it bears a pair of black curved thickenings (*a.th*), and sometimes a second pair (*p.th*) lies behind the anterior pair. That portion of the plate posterior to the level of the thickenings is much more heavily chitinised than the anterior portion, in which a large transparent space occurs medianly. The upturned anterior processes (*a.p*) which are a marked feature of the signum tend to slight variation, and are much smaller in one individual than those shown in the illustration.

Belgian Congo : River Kwango, Kasongo Lunda, 24.x.1920, 2 ♀♀ ; River Kwango, near Cuango, 24.x.1920, 4 ♀♀ (' Le soir par terre ') 25.x.1920

3 ♀♀; River Kwango, near Kundi, 1.xi.1920, 2 ♂♂ ('Le soir sur chemin') Dr. J. Schwetz.

In its general external facies the male of this species bears a striking resemblance to that of *Gl. tabaniformis*, West; the female, on the other

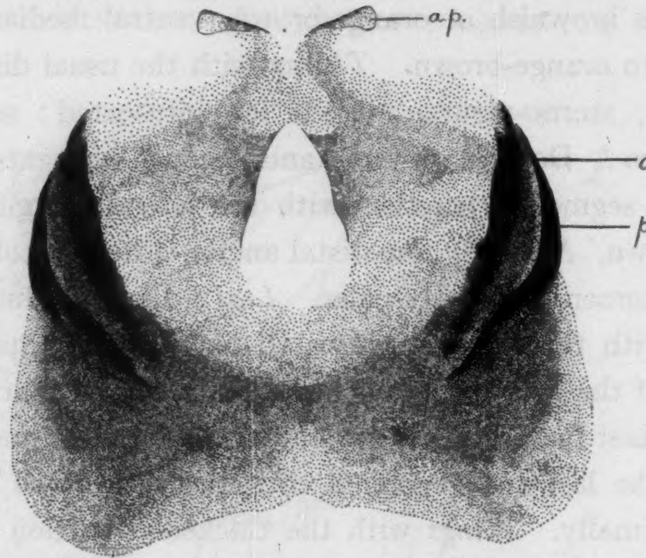

FIG. 2. *Glossina schwetzi*, sp. n. ♀. Signum × c. 155.
a.p., anterior process; *a.th.*, anterior thickening; *p.th.*, posterior thickening.
(Genital fossae not shown.)

hand, owing to the darker colour of the thickened portion of the anterior transverse vein, might easily pass as a specimen of *Gl. brevipalpis*, Newst. Both sexes may, however, be readily distinguished from any other members of the '*Fusca* Group' by the strikingly characteristic genital armature.

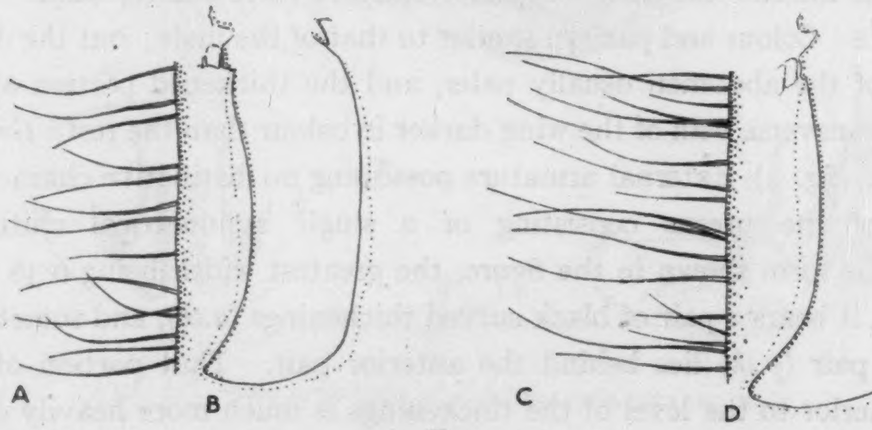

FIG. 3.
Glossina schwetzi, sp. n., *A.*, antennal fringe × c. 325; *B.*, third segment of antenna × c. 40.
Glossina tabaniformis, *C.*, antennal fringe × c. 325; *D.*, third segment of antenna × c. 40.

Furthermore, the antenna of *Gl. schwetzi* can be distinguished from that of *Gl. tabaniformis* by the shorter fringe of fine hairs on the anterior edge of the third segment (fig. 3). The ratio of the length of the longest fringe-hairs to the greatest width of the segment was determined

in four specimens of each of the above-named species. They are tabulated below :

Gl. schwetzi, sp. n.	1 : 5·9	1 : 6·2	1 : 7·1	1 : 7·5
Gl. tabaniformis	1 : 3·7	1 : 4·1	1 : 4·3	1 : 4·3

COMPARATIVE TABLE OF THE MORPHOLOGICAL CHARACTERS OF THE MALE GENITAL ARMATURE

	Gl. schwetzi	*Gl. tabaniformis*
Harpes :	Fig. 1	Fig. 1, no. 3
Proximal process ...	A stout spine, one-fourth length of second.	Slender and equal in length to the second.
Second process... ...	Slender.	The same.
Third process (distal) ...	Long, slender and simple.	Long and strongly bifurcate.

COMPARATIVE TABLE OF THE MORPHOLOGICAL CHARACTERS OF THE FEMALE GENITAL ARMATURE

	Gl. schwetzi	*Gl. tabaniformis*
Signum of uterus... ...	Fig. 2	
	With a bilateral pair of black curved thickenings.	Lyriform. No bilateral curved thickenings.
Long axis	Transverse.	Longitudinal.

GLOSSINA FUSCA var. *CONGOLENSIS*, var. nov.

Colour and pattern generally as in typical Gl. fusca, Walker, but the wings are usually more heavily infuscated. Harpes of male (fig. 4) *with the proximal process reaching to the tip of the second (serrated) process. Bilateral portions of the signum of the uterus of the female sub-rotund.*

MALE : *Genital armature* (fig. 4). Harpes (*h*) with the narrow proximal process reaching to the tip of the second, serrated process ; the latter relatively narrow, and more or less suddenly truncate distally ; the third, a somewhat sickle-shaped appendage, with the distal arm very much shorter than the proximal one.

FEMALE : *Genital armature*. In the signum of the uterus (fig. 5) the width is greater than the length ; the bilaterally symmetrical plates forming the main portion of the signum sub-rotund, and separated medially by only a very shallow depression.

The foregoing description, and also the illustrations which accompany it are based upon fourteen examples, representing both sexes, captured in

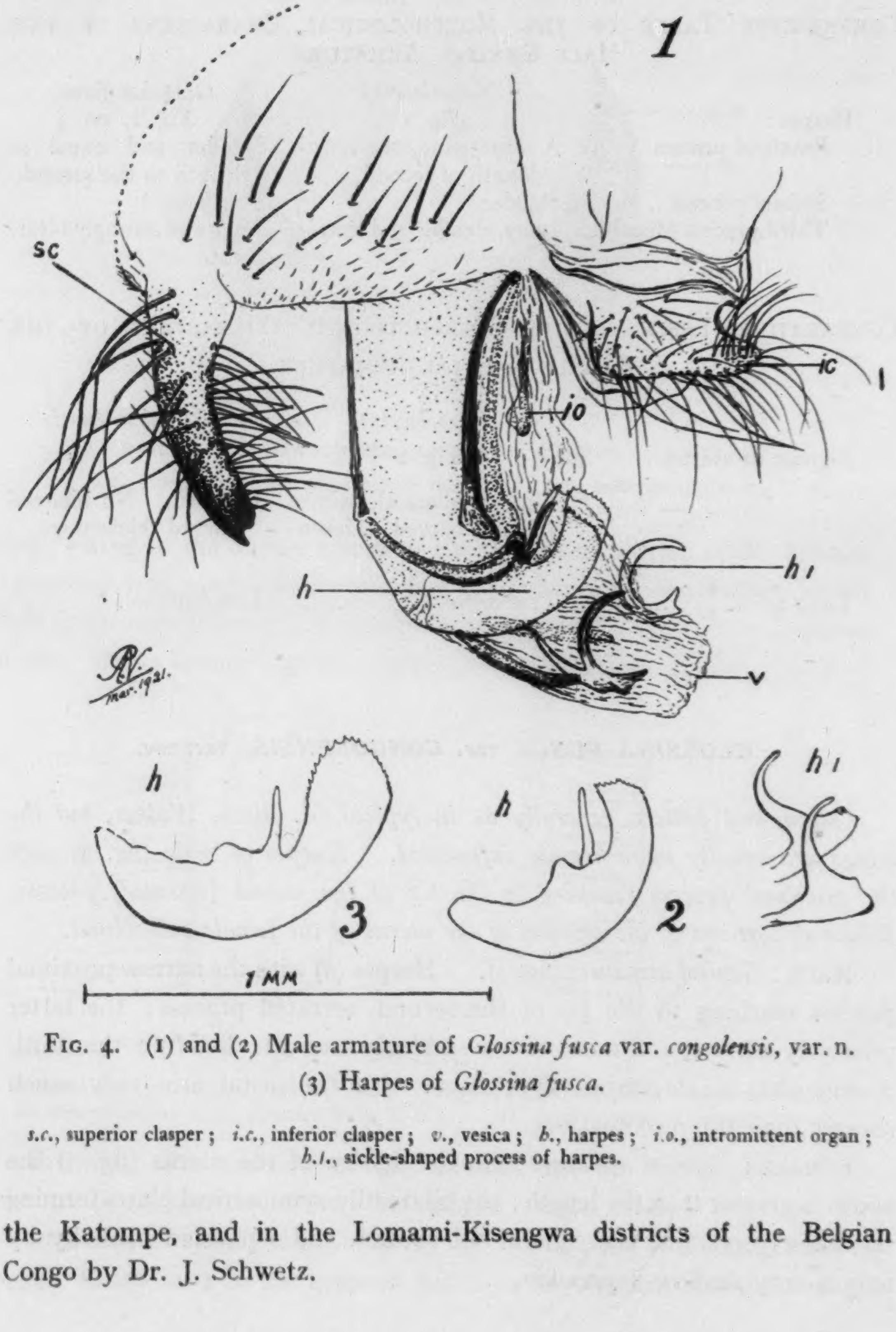

FIG. 4. (1) and (2) Male armature of *Glossina fusca* var. *congolensis*, var. n. (3) Harpes of *Glossina fusca*.

s.c., superior clasper; *i.c.*, inferior clasper; *v.*, vesica; *h.*, harpes; *i.o.*, intromittent organ; *h.1.*, sickle-shaped process of harpes.

the Katompe, and in the Lomami-Kisengwa districts of the Belgian Congo by Dr. J. Schwetz.

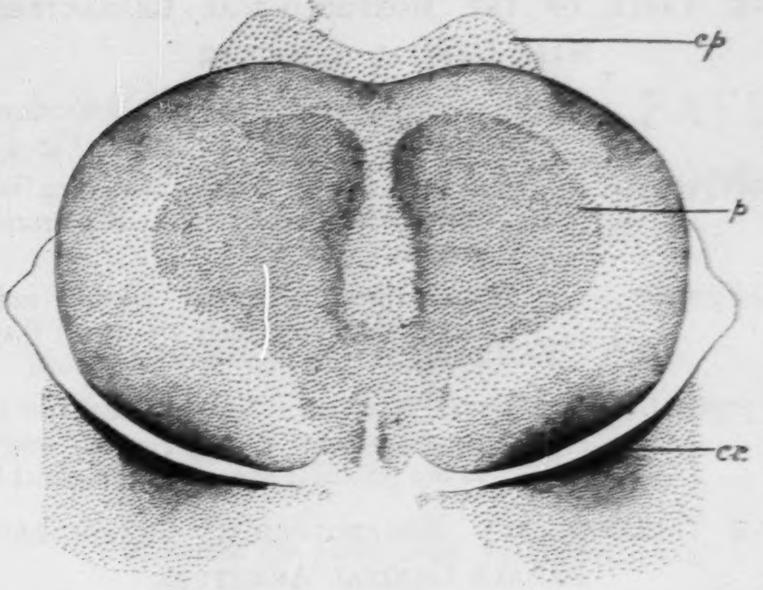

FIG. 5. *Glossina fusca* var. *congolensis*, var. n. ♀. Signum × c. 155.
c.p., anterior plate; *cr.*, crescentic thickening; *p.*, petaloid area. (Genital fossae not shown.)

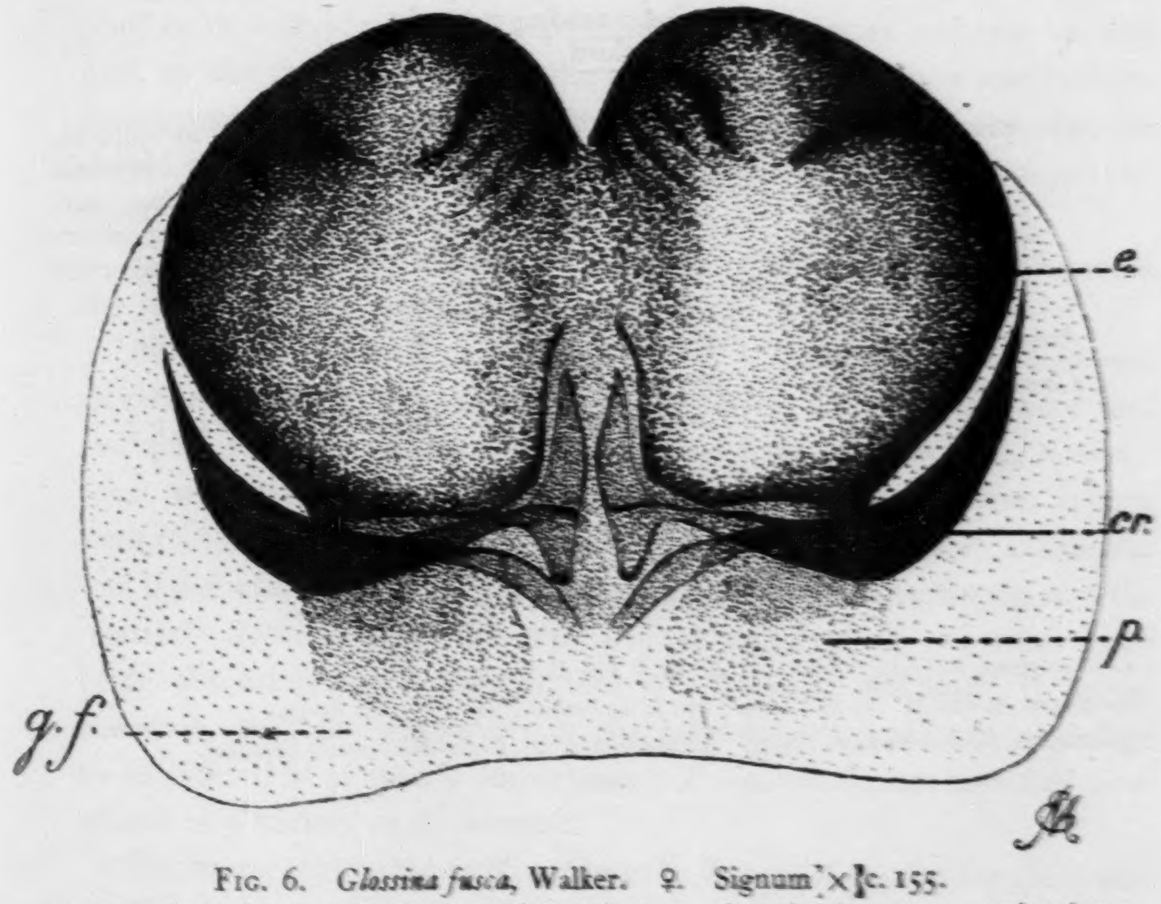

FIG. 6. *Glossina fusca*, Walker. ♀. Signum × c. 155.
cr., crescentic sclerite; *e.*, half of main portion of signum; *g.f.*, genital fossae; *p.*, posterior plate.

Comparative Table of the Morphological Characters of the Male Genital Armature

	G. fusca Fig. 4, no. 3	*G. fusca var. congolensis* Fig. 4, no. 1, 2
Harpes :		
Proximal process ...	Reaching to the middle distance of the serrated process.	Reaching to the tip of the serrated process.
Serrated process ...	Distally broadly lanceolate ; shaft relatively broad.	Distally suddenly truncate ; shaft relatively narrow.
Distal process ...	Distal arm of sickle-shaped process as long as the proximal one.	Distal arm less than half the length of the proximal one.

Comparative Table of the Morphological Characters of the Female Genital Armature

	Gl. fusca	*Gl. fusca var. congolensis*
Signum	Fig. 6	Eig. 5
Halves of main portion ...	Sub-conical. Very markedly convex, separated anteriorly by deep V-shaped depression extending to nearly one-third of their depth.	Sub-rotund. Slightly convex, separated anteriorly by very shallow depression.
Chitinisation	Generally complete, the colour varying from deep ochraceous to black.	Generally incomplete, ochraceous petaloid area (*p.*) often surrounded by considerable almost colourless area.
Anterior plate (*c.p.*) ...	Absent.	Generally present.
Greatest width	Average 0·56. Extremes 0·60, 0·46.	Average 0·42. Extremes 0·44, 0·40

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ON A COLLECTION OF PAPPATACI FLIES (*PHLEBOTOMUS*) FROM INDIA

BY

PROFESSOR R. NEWSTEAD, F.R.S.,

AND

MAJOR J. A. SINTON, V.C., I.M.S.

(*Received for publication* 14 *March*, 1921)

The collection of insects which form the subject of this communication was made by one of us (J. A. Sinton) in the North-west Province of India, with the exception of the single capture of a specimen of *Phlebotomus major*, Annandale, at Simla. It embraces the records of a very large number of individuals (664) representing three species and one variety, and, as the pappataci flies of the region in question have not hitherto been investigated, it seemed desirable that a complete list of the captures should be recorded, the subject being a cognate one to that of pappataci fever.

The occurrence of *Phlebotomus sergenti*, Parrot, is of much interest, the species being a new addition to the fauna of India.

In the examination of the long series of examples of *Phlebotomus minutus*, Rond., it was found to be impossible to draw any hard and fast lines for the separation of this species from *P. antennatus*, Newst.,[1] since we found so many intermediate forms ranging between typical examples of each. It may be recalled that the erection of *P. antennatus* was based chiefly upon the remarkably short antennal segments, and the relatively shorter legs; the male genital armature on the other hand being absolutely identical with that of typical *P. minutus*. It seems, therefore, that the differences in the antennal segments can no longer be considered as of specific importance; *P. antennatus* has therefore been placed as a variety of *P. minutus*.

We tender out thanks to Miss Alwen M. Evans, M.Sc., for her assistance in the preparation and determination of the material.

Phlebotomus papatasii, (Scop).

In the males twelve examples were found to possess an additional spine on the inferior clasper of the genetalia; in some instances the spine was bilateral, in other cases unilateral. One example also possessed a supernumerary spine on the left superior clasper.

INDIA: NORTH-WEST FRONTIER PROVINCE. DERA ISMAIL KHAN, 2 ♂♂, 6 ♀♀, bedroom, bungalow, September and October, 1919; 6 ♂♂, 7 ♀♀, ditto, 14.iv.1920 to 14.v.1920; 40 ♂♂, 52 ♀♀, cowshed, 8.iii.1920 to 31.iii.1920; 35 ♂♂, 74 ♀♀, ditto, 1.iv.1920 to 14.iv.1920; 3 ♂♂, 10 ♀♀, ditto, 15.iv.1920 to 15.v.1920; 1 ♂, tents near I.M.S. bungalow, 16.iii.1920; 4 ♂♂, 11 ♀♀, ditto, 12.iv.1920 to 15.v. 1920. TANK, 1 ♂, 5 ♀♀, inside tents with floors sunk 3 feet, 29.viii.1919, 1.ix.1919, 16.ix.1919; 2 ♀♀, ditto, 6.iv.1920. BANNU, 4 ♂♂, 1 ♀, bedroom, bungalow, 11.viii.1919 to 12.viii.1919. IDAK, TOCHI VALLEY, 1 ♀, mud barracks, 26.viii.1919. SAGGU, near DERA ISMAIL KHAN, 1♀, stable, 14.iii.1920. JATTA POST, 1 ♀, mud barracks, 7.iv.1920. MURTAZA, 1 ♂, 4 ♀♀, mud barracks, 1.ix.1919; 1 ♂, 6 ♀♀, ditto, 7.iv.1920. HATHALA, 1 ♂, 1 ♀, mud barracks, 29.viii.1919; 1 ♀, ditto, 6.iv.1920.

Phlebotomus minutus, Rondani.

The specimens showed a marked variation in colour; every form intervening between the pale typical examples and distinctly dark or melanic forms were observed. The left superior clasper in one male possessed a supernumerary spine. The wings of this species also showed a marked tendency to variation, both as regards size and contour, and also in the relative length of the anterior forked vein.

INDIA: NORTH-WEST FRONTIER PROVINCE. DERA ISMAIL KHAN, 118 ♂♂, 34 ♀♀, bedroom, bungalow, September and October, 1919; 6 ♂♂, 2 ♀♀, ditto, 14.iv.1920 to 14.v.1920; 3 ♂♂, 7 ♀♀, cowshed, 8.iii.1920 to 31.iii.1920; 15 ♂♂, 8 ♀♀, ditto, 1.iv.1920 to 14.iv.1920; 1 ♂, 3 ♀♀, tents near I.M.S. bungalow, 16.iii.1920; 36 ♂♂, 13 ♀♀, ditto, 12.iv.1920 to 15.v.1920. TANK, 3 ♂♂, 6 ♀♀, tents with floors sunk 3 feet, 29.viii.1919, 1.ix.1919, 16.ix.1919. BANNU, 37 ♂♂, 37 ♀♀, bedroom, bungalow, 11.viii.1919 to 12.viii.1919. IDAK, TOCHI VALLEY, 2 ♂♂, mud barracks, 26.viii.1919. KHIRGI, 2 ♀♀, tents, 30.viii.1919. HATHALA, 3 ♀♀, mud barracks, 29.viii.1919.

Phlebotomus minutus var. *antennatus*, Newst.

Phlebotomus antennatus, Newst. *Bull. Ent. Res.*, Vol. III, p. 365.

The variation in colour from light to dark or melanic forms was similar to that found in *P. minutus*, but none possessed the intense lapis-lazuli colour found in the West African forms.[5]

INDIA: NORTH-WEST FRONTIER PROVINCE. DERA ISMAIL KHAN, 11 ♂♂, 3 ♀♀, bedroom, bungalow, September and October, 1919; 2 ♂♂, ditto, 14.iv.1920 to 14.v.1920; 2 ♂♂, 1 ♀, cowshed, 8.iii.1920 to 31.iii.1920; 1 ♂, 2 ♀♀, ditto, 1.iv.1920 to 14.iv.1920; 1 ♂, 2 ♀♀, tents near I.M.S. bungalow, 12.iv.1920 to 15.v.1920, TANK, 3 ♀♀, tents with floors sunk 3 feet, 29.viii.1919, 1.ix.1919, 16.ix.1919. BANNU, 2 ♂♂, 7 ♀♀, bedroom, bungalow, 11.viii.1919, 12.viii.1919.

Phlebotomus sergenti, Parrot.

Parrot[2] first described this species from Algeria; subsequently it was found by Marzinovsky[3] at Tiflis, by Sinton in Persia, and by Buxton[4] in Mesopotamia. Hitherto it does not seem to have been recorded from India.

INDIA: NORTH-WEST FRONTIER PROVINCE. DERA ISMAIL KHAN, 1 ♂, cowshed, 8.iii.1920 to 31.iii.1920; 1 ♂, tents near I.M.S. bungalow, 12.iv.1920 to 15.v.1920; 3 ♂♂, 1 ♀, stable, TANK ROAD, 7 miles from DERA ISMAIL KHAN, 6.iv.1920. MURTAZA, 1 ♂, mud barracks, 1.ix.1919.

Phlebotomus major, Annandale. *Records Indian Mus.*, Vol. V, p. 46 (1910).

INDIA: SIMLA, 1 ♀, 30.v.1920.

Colour and general facies resembling those of the female in *P. papatasii*, but the wings are relatively longer and narrower. Position of abdominal hairs doubtful owing to the rubbed condition of the dorsal surface, but the hairs on the venter more or less erect. Palpi with the 2nd, 3rd, and 4th segments sub-equal in length; the 5th twice the length of the 3rd.

Total length of head and body, 3·5 mm.; length of wing, 3·3; greatest width, 1·05 mm.; length of leg ii, 4·8 mm.; femur more than half the length of the tibia, the latter equal in length to the first three proximal segments of the tarsus.

This, as may be gathered from the above details, is an exceptionally large species, and in its general facies and certain structural characters agrees with Annandale's description of his *P. major* (*l.c.*). There are some

important discrepancies however : i.e., in the arrangement of the abdominal hairs, and the length of the body as compared with that of the legs. We feel, however, that these may be considered as possible mutations within the range of variation of the species, and have therefore placed it here.

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5.——— (1920). *Bull. Ent. Res.*, Vol. XI, p. 305.

ADDENDUM

Vol. XV, p. 96. Paper by Newstead and Evans. Add to explanation of FIG. 1: '2: Ventral view of the armature of *Glossina schwetzi*. 3: Harpes of *Glossina tabaniformis* in profile.'

NOTES ON ORIENTAL SORE IN RUSSIAN TURKESTAN AND THE RESULTS OF TREATMENT WITH INJECTIONS OF TARTAR EMETIC SOLUTION

BY

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(*Received for publication 27 April, 1921*)

The cases reported below seemed worthy of record on account of the rapidity with which they reacted to treatment with intravenous injections of solutions of tartar emetic, a treatment which does not seem to have been tried previously in Turkestan.

This disease is very widely spread in Russian Turkestan, and is said to be found in all the towns on the Trans-Caspian Railway from Askhabad to Tashkent. Yakimoff and Schockov (1915) described it at Askhabad, Boukhara, Samarkand and Termèze, and in the latter place it seemed especially prevalent.

Locally it is said that practically every person residing in Turkestan for five years has the marks of at least one of these sores. At Tedjen station, on casual inspection, about 50 per cent. of the people seemed to have marks of old sores on their faces, but the authors quoted above state that only 58·2 per cent. of the sores examined by them were leishmaniasis. The same authors report two cases of cutaneous leishmaniasis in dogs in Turkestan.

In all the six cases noted below *Leishmania tropica* were found. The treatment used was intravenous injections of 2 per cent. solution of antimonium tartaratum (tartar emetic) in normal saline solution; the sores received no special local treatment. Except for a little vomiting immediately after the injection, in two cases, no constitutional effects were caused by the injections.

NOTES ON THE CASES

CASE 1. Russian Nursing Sister at Kaakha, Turkestan.

History. Resident in Turkestan for some years. Duration of sores about three months.

Condition. (*a*) A small raised nodular sore ¼-inch in diameter at the angle of the left jaw, with slight ulceration in the centre. (*b*) Three similar sores on the left forearm.

Treatment. 5.10.18. Intravenous injection of 3 c.c. T.E. solution.
7.10.18. Injection of 4 c.c. T.E. solution.

Result. On account of military operations the case was not seen again until 14.11.18, at which time all the sores were healed and the patient reported that they had all healed within three weeks after the injections.

CASE 2. Sepoy A.S.

History. Patient has been in Turkestan about three months. Duration of lesion uncertain.

Condition. Sore about ½-inch diameter on right hand. Warty and ulcerated.

Treatment. 19.1.19. Intravenous injection of 2 c.c. of T.E. solution.
22.1.19. Injection of 3 c.c. of T.E. solution.

Result. Completely healed by 27.1.19.

CASE 3. Sepoy M.K.

History. Had a small abrasion on the back of the left hand about 1.10.18, at Meshed, N. Persia, which gradually got bigger. He arrived in Turkestan on 10.10.18.

Condition. On 7.1.19, at Bairam Ali, Turkestan. A large sore about 1½ inches in diameter on back of left hand with inflamed margins and a warty base. No enlarged glands or thickening of the lymphatic vessels.

Treatment. 14.1.19. Injection of 2 c.c. of T.E. solution.
16.1.19. " " 3 c.c. " "
19.1.19. " " 4 c.c. " "
22.1.19. " " 5 c.c. " "

Result. The warty growth gradually shrivelled and the ulceration disappeared. Completely healed on 28.1.19.

CASE 4. Sepoy S.S.

History. Got an abrasion of the left hand at Dushak, Turkestan, on 14.10.18, which gradually increased in size. Duration three months.

Condition. (*a*) A large circular lesion about 2½ inches in diameter on back of left hand with infiltrated edges and a warty base with slight ulceration in the centre. (*b*) A few small non-ulcerated nodules in the adjacent skin.

Treatment. 14.1.19. Injection of 2 c.c. of T.E. solution.
16.1.19. " " 3 c.c. " "
19.1.19. " " 4 c.c. " "
21.1.19. " " 5 c.c. " "

Result. After the second injection, a firm nodule the size of a pea was discovered in a lymphatic vessel about 2½ inches below the elbow at the back of

the left forearm, and a soft swelling about 2 inches by 1 inch on the inner side of the same forearm. This swelling was on the opposite side to that on which the injections had been given. Marked improvement was noted at the time of the third injection, the sore being dry in the centre and the warty growth shrivelling. The sore was completely healed on 29.1.19.

CASE 5. Sepoy C.D.

History. Said to be of two weeks' duration. No history of wound or abrasion. Patient has been several months in Turkestan.

Condition. At the beginning of January, 1919.

(*a*) A circular lesion with thickened edges and a warty base about 1 inch in diameter on front of left wrist.

(*b*) Two small nodules in the lymphatic vessels about two inches above the sore.

Treatment.	14.1.19.	Injection of 2 c.c. of T.E. solution.
	16.1.19.	„ „ 3 c.c. „ „
	19.1.19.	„ „ 4 c.c. „ „
	22.1.19.	„ „ 5 c.c. „ „

Result. The warty growth rapidly shrivelled and the nodules disappeared from the lymphatics. Completely healed on 27.1.19.

CASE 6. Sepoy N.S.

History. He has been in Turkestan four months. He states that the lesions began with great itching and appeared more or less simultaneously. Duration about one month.

Condition. On 1.1.19.

(*a*) On the front of the left wrist was an oval sore about 1 inch by ¾ inch, with thickened edges and a warty centre, but no ulceration.

(*b*) On the front of the right forearm:

(1) A circular lesion, 1 inch in diameter, with heaped-up and thickened edges, having an ulcer ½-inch in diameter in the middle with a granulating base.

(2) A small sore ½-inch in diameter, with a thickened raised edge and a minute ulcer in the centre like a boil.

(3) There were two small nodules in the lymphatic vessels about two inches *below* these sores, and there were no enlarged glands.

Treatment.	16.1.19.	Injection of 1 c.c. of T.E. solution.
	19.1.19.	„ „ 3 c.c. „ „
	22.1.19.	„ „ 3 c.c. „ „

Result. At the time of the first injection some of the solution passed under the skin because the patient suddenly moved his arm. At the time of the second injection there was marked thickening and some inflammation at the site of the previous injection. Improvement was noticed in the sores on 22.1.19, and this was marked on 25.1.19. There was still some infiltration of the area around the point of first injection on 25.1.19, but there was no suppuration. Completely healed on 30.1.19.

These cases may be summarised as follows:—

TABLE I.

Case No.	Duration before treatment	Amount of T.E. injected	Number of injections	Duration of treatment in days	Number of days till cured.
		cgms.			
1	3 months	14	2	3	? 21
2	?	10	2	4	8
3	3½ months	28	4	9	14
4	3 months	28	4	9	15
5	½ month	28	4	9	13
6	1 month	14	3	7	14
Average	2·2 months	20·33	3·1	6·8	14·1

An analysis of the clinical signs in these six cases shows that Cases 2, 3, 4, 5 and 6 correspond to the 'cutaneous hypertrophic non-ulcerating papillomatous' type of da Matta's classification (1916) of the leishmaniases, but in this type in these Turkestan cases it was found that after a certain time these warty growths tend to ulcerate in the centre. As they bleed very easily, this ulceration seems most probably due to injury followed by a secondary infection.

In Cases 1 and 6 the typical 'Oriental Sore' of the text-book was found.

In Cases 1, 4 and 6 the lesions were multiple, and in Case 6 both the papillomatous type and the typical oriental sore were found. Yakimoff and Schockov (1915) state that a single sore is commonest, but as many as seventeen may occur.

In Cases 4, 5 and 6 nodules were present in the lymphatic vessels within a few inches of the sores, those in Case 6 being remarkable in that they were distal to the lesions.

The attached table gives a comparison between the results of treatment with intravenous injections of tartar emetic solution only, in the cases reported by myself (1917), in those reported by Greig (1917) in the same year, and in the present cases.

TABLE II.

	Sinton, 1917	Greig, 1917	Sinton, 1919
Where contracted	N.W. Frontier, India and Mesopotamia	Mesopotamia	Russian Turkestan
Number of cases treated	6	18	6
Average duration of the disease before treatment ...	2 months	2·6 months	2·2 months
Duration of the treatment in days :—			
Average	20	...	6·8
Maximum	37	...	9
Minimum	8	...	3
Number of days from commencement of treatment till cured :—			
Average	28·3	28·2*	14·1
Maximum	51	52*	21 (?)
Minimum	12	16*	8
Amount of T.E. given intravenously :—			
Average	38·2 cgms.	71·5 cgms.	20·33 cgms.
Maximum	89 cgms.	150 cgms.	28 cgms.
Minimum	12 cgms.	20 cgms.	10 cgms.
Number of injections given :—			
Average	5·3	?	3
Maximum	9	?	4
Minimum	3	?	2
Result :—			
Cured	6	17	6
Not cured	0	1	0

*NOTE.—These figures are probably excessive, as they represent the 'number of days under observation in hospital.'

From this table it will be seen that the amount of tartar emetic needed to produce a cure in the Turkestan cases was only half to one-third of that needed in the other cases, and the rate of cure was almost twice as rapid.

Although it is not possible to draw any definite conclusions from so few cases, yet it would seem probable that the variety of sore found in Turkestan is more amenable to treatment with antimony than the Mesopotamian type.

I am indebted to Dr. Minkavitch, of the Russian Medical Service, for the following details of the treatment adopted for the cure of this disease by some medical practitioners in Turkestan. This treatment is a modification of the local native treatment.

A piece of Emplastrum Cantharidis is cut slightly larger than the sore; this is placed over the sore and completely covered by a larger piece of adhesive plaster to hold it in position. This dressing is renewed daily, and the blisters which have formed are opened. This treatment is continued for four days, after which the sore is treated with some simple ointment. Some very good results are said to be obtained by this treatment, but the scar left is large.

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A METHOD FOR THE CULTIVATION OF BLASTOCYSTIS

BY

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Quite a good deal of uncertainty has existed as to the true nature of blastocystis. Prowazek (1904) and Ucke (1907) first described this organism as a cyst of trichomonas. Alexeieff (1911) was the first to describe blastocystis as a distinct organism of a vegetable nature. Others have described this organism and discussed the possibility of its being a cyst of trichomonas or other intestinal parasite, or some degeneration form of these parasites.

Bohne and Prowazek (1908), Benson (1909), Wenyon (1910), Prowazek (1911), Brumpt (1912), Chatton and Lalung Bonaire (1912), Macfie (1915), Swellengrebel (1917), Chatton (1917), have all given various descriptions of this organism. Wenyon (1920) gives a very comprehensive review and digest of the subject. Parts of his article are quoted below:—

'What then is the blastocystis which occurs so commonly in the human intestine and that of other animals? Prowazek (1911) maintained that they were cysts of trichomonas, but there is no evidence to support this view. Swellengrebel (1917) has suggested that they are degenerate forms of various intestinal protozoa, while Jepps and Dobell (1918) have noted that certain degenerate forms of *Dientamoeba fragilis* resemble dead blastocystis. I myself have, for want of evidence to the contrary, always regarded them as of a vegetable nature, and this may be the case in spite of the resemblance to the cysts of *Prowazekella lacertae*. Swellengrebel's conclusion is that blastocystis "is not the name of a zoological genus but of a peculiar form of degeneration to which representatives of different genera of intestinal protozoa may be liable."' Wenyon concludes, 'It is evident, therefore, that there is a difference of opinion as to the true nature of blastocystis, and we must await further information.'

The writer has had under observation for the past few years a case of balantidial infection, whose stools are loaded with blastocystis as well as balantidia. While attempting to cultivate the balantidia, the blastocystis was found to multiply readily on the medium used. Since then numerous cultures from different individuals have been made. This work was begun in 1919, and the first successful culture made in September of that year. The universal occurrence of this organism may be noted from the articles by Lynch (1917) in the United States, Wenyon and O'Connor (1917) in Egypt, Haughwout (1918) in the Philippines, and Maplestone (1921) in Australia.

METHOD

The culture medium used in this work is very simple, being made up of human blood serum and 0·5 per cent. of sodium chloride solution. Various concentrations of the serum in salt solution have been tried. The most favourable strength has been 10 per cent. Walker (1913) found 0·5 per cent. salt solution to be the proper tonicity for *Balantidium coli*, and this concentration has been used in the work with blastocystis. The salt solution is sterilized in the autoclav and the serum added after inactivation at 55° C. for one half-hour. The pooled serum of several individuals has been used instead of that from a single individual, although no work has been done to show whether or not one serum may be inhibitory while another is favourable to the growth of blastocystis. The sera of animals other than man have not been tried. This medium is faintly alkaline to litmus. The medium is distributed in narrow test tubes in quantity sufficient to give a column of fluid at least 100 mm. high.

No growth takes place at the surface of the tube, and the parasites multiply best at the lower portion of the tube, evidently needing little free oxygen for their growth.

In making the initial inoculation, a small portion of stool or an emulsion of faeces in salt solution is placed at the bottom of the tube containing the culture medium. The culture is incubated at 37° C. for twenty-four to forty-eight hours and then examined for blastocystis. It is best to examine early cultures every twenty-four

hours in order to note the degree of growth of blastocystis and to make transfers before bacterial contamination is too heavy. If good growth is obtained after twenty-four hours, a transplant is then made into fresh culture medium, using the sediment in the original tube. When the organisms have established themselves in the new medium, it is best to make transfers every forty-eight hours. Cultures seventy-two hours old, or older, will hardly ever give good growth in succeeding transfers. As stated above, the optimum growth takes place in the lower portion of the tube. In making all subsequent transfers the sediment from the cultures is used, and is introduced into the bottom of the tubes of the fresh medium. Using this method, the writer has carried blastocystis through more than twenty-five sub-cultures, covering a period of about fifty days. Cultures have been abandoned, usually because of pressure of other work or because of accident or carelessness in making transfers, although they often die from bacterial overgrowth. With proper care a culture can probably be carried on indefinitely. The writer has made no attempt to classify different strains of blastocystis though the gross appearance of organisms from different individuals would suggest strongly that several strains of blastocystis have been encountered. Nor has any attempt been made to trace out a developmental cycle for blastocystis. This task is properly left to one proficient in systematic mycology.

In cultures, budding, as described by Alexeieff, and binary division are the methods of multiplication exhibited by this organism; both of these processes have been observed in all cultures. In the examination of hundreds of preparations the so-called multiple division form of Alexeieff, pictured by Wenyon and O'Connor (1917), has been encountered on only two occasions. This form would seem to be some freak in the development of the organism rather than a true developmental phase. In cultures, as in the intestinal contents, a great variation in the size of the organisms is observed. It may be said with a reasonable degree of certainty that the large vacuolated forms are the result of degeneration, as these forms are commonly found in old cultures, and successful transfers cannot be made from cultures made up of these forms. No flagellate forms, and no forms showing amoeboid or other motion have been encountered. Blastocystis retains its original form after twenty-five successive transfers

in artificial culture medium, and no forms were seen in the twenty-fifth transfer that were not seen in the first.

This work is submitted as proof that blastocystis is a distinct zoological genus, and not a cyst of protozoa nor a form assumed by protozoa undergoing degeneration.

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THE INCIDENCE OF INTESTINAL PARASITES, ESPECIALLY WITH REGARD TO THE PROTOZOA, AMONGST SYMPTOMLESS CARRIERS IN JAMAICA.

BY

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The objects of this investigation were, firstly, to find out the incidence of infection with various species of intestinal parasites in patients admitted to hospital for conditions totally unconnected with dysentery or other intestinal complaints, *i.e.*, symptomless carriers, and, secondly, to see what strains of amoebae were common.

That three successive examinations should indicate freedom from infection was a purely arbitrary standard, and is shown later to be erroneous in some at least of the cases in this series.

We must bear in mind that a 'negative examination' does not mean that no cysts are present; it, of course, merely implies that none have been found, and, when we consider how small a proportion of the whole stool is submitted to examination, we can understand that if the cysts are few in number they may easily be missed in such a limited examination. Again, if only one or two are found after thorough examination of several specimens, though the results will be erroneous from the statistical point of view if put down as negative, owing to none being found in the first three specimens, nevertheless the infection is probably so slight that for all practical purposes the stool is negative.

In this connection, however, it is also important to remember that the value of a negative report on examination will differ somewhat according to the species of parasite. Thus, a negative examination in respect of *Giardia intestinalis* is more likely to be correct, as

regards inference, than one in respect of *Entamoeba coli*, owing to the more general and even distribution of the former in a stool; while the latter are often so irregularly distributed through the faeces that one sample taken for examination is by no means representative of the whole stool. Under conditions such as the latter, two observers examining different portions of the same stool might give diametrically opposite reports: the one that he could not find any, the other that *coli* cysts were abundant. In cases of *Giardia* infection this is less likely to occur.

In order to minimise this difficulty as far as was practicable, instead of taking these specimens from a stool and examining direct, I have adopted the concentration method of Cropper and Row (1917). By this means, not only was the examination facilitated, but one was able to employ larger quantities for examination, and, by the prolonged shaking and consequently more thorough emulsification, to obtain specimens more representative of the general state of the stool.

A second branch of investigation was also undertaken, as the opportunity to add something to the knowledge of the size of cysts in different persons infected was too good to be lost. All who have undertaken the measurement of a large number of cysts of the various parasites will appreciate the tediousness and labour involved in doing this day after day, but it appeared to me that it would be a matter of interest and possible utility to see whether the researches of Matthews and Malins Smith (1917) in Liverpool cases were corroborated by the findings in patients in Jamaica.

With a pressure of routine work, and having no trained assistants, I have been able to deal with a limited number of cases only, very limited indeed as compared with the large numbers examined and reported upon by the two authors mentioned, and in putting forward my results, I do so with a feeling of diffidence, since, owing to the limited time and resources at my disposal, I do not intend them as a comparison with their brilliant work.

The remarks which follow, however, will serve as a good basis for further investigation which can be continued at any time, and also as a basis for comparison with similar cases in other tropical countries.

The method which has been employed is as follows :—Cases for

examination were selected from among patients in the hospital to which the laboratory is attached. Those patients who had been admitted for any intestinal condition were excluded. It was desired to find out whether any of those admitted to hospital for complaints other than intestinal were harbouring parasites. Since these patients would leave hospital as soon as they recovered, they would then become healthy carriers, as regards the intestinal parasites present.

A certain number of male and female patients were selected, and fresh stools from them were sent to the laboratory on alternate days for three weeks; on the intermediate days a similar series of an equal number of patients was sent. Two series of patients could thus be dealt with at the same time, or rather during the same period, the stools from one series being brought to the laboratory on Mondays, Wednesdays and Fridays, and those from the other on Tuesdays, Thursdays and Saturdays. Since no specimens were sent up on Sundays, each case was examined on the first, third, fifth, eighth, tenth, twelfth, fifteenth, seventeenth, and nineteenth days.

As none of the patients showed any signs of intestinal infection they were not under any treatment for the condition even when protozoal infection was detected, so that the natural course and variations could be followed during the period of examination.

As Dobell (1917) has stated: 'A minimum of six examinations per case should be adopted (it is an arbitrary number), no case being regarded as free from infection [he is speaking of *Entamoeba histolytica*] unless it has been examined six times with negative results. Untreated cases may be examined on any six days convenient to the examiner, since there is no evidence of periodicity in the occurrence of positive or negative examinations. Since the distribution appears to be at random, the chances of finding the infection, if present, are as great for any one day as any other.'

The case J. T. affords an example in which infection with *E. histolytica* was not detected until the last examination of all; six examinations would have failed to find this one.

The period of three weeks being decided upon, each patient's stools, if the actions were regular, were examined on nine occasions. Cropper and Row's concentration method was adopted, and was found to facilitate matters greatly when later we came on to the

mensuration of the cysts. There is no need to detail the method; suffice it to say that after concentration three separate specimens were examined from each before the stool was pronounced negative for the day.

Examination for helminth ova was also made on the first day that the stools were sent; if these were found, no further search was made for them on subsequent occasions, as the percentage of cases infected with these ova has been given in detail in my reports from Jamaica for several years, totallin- over 40,000 specimens. If, however, none were found on the first day, their presence was noted when one came across them later in searching for protozoal cysts.

The tables appended show the distribution of the various parasites found, the cases being arranged according to age. It will be seen that the stools from one hundred and two patients have been submitted to examination, of which fifty-three were males and forty-nine females.

In twenty-one of the forty-nine female cases the *Entamoeba coli* was found during these examinations, and in six the *E. histolytica*. It will be noticed that in only one of these was the latter found without the former. Cysts of *Giardia intestinalis* were found alone in four instances, and in combination with other forms in eleven. *Chilomastix mesnili* was met with seven times and *Balantidium coli* once only.

Comparing these figures with the numbers found among the fifty-three male cases: *E. histolytica* was found in nine, *E. coli* in twenty-seven, *G. intestinalis* in twenty-one (in four of these they were present alone), *C. mesnili* was found in six, and *B. coli* in one.

Thus, out of the total of one hundred and two patients whose stools were examined, *E. coli* was found in forty-eight, or just over 47 per cent.; *E. histolytica* in fifteen, or 14·7 per cent.; *G. intestinalis* in thirty-six, or 35·29 per cent.; *C. mesnili* in thirteen, or 12·74 per cent.; and *B. coli* twice.

Cercomonas sp. occurred fairly frequently, but no record was kept of this. It is seen in a considerable number of the ordinary routine specimens sent to the laboratory for examination for ankylostome ova.

These proportions, when we consider that none of the patients gave any history, at all events recent, of intestinal troubles, are very

high, and it was my intention to continue the investigation to see whether subsequent series maintained this high percentage, but my transfer to Hong Kong has prevented this.

Before considering each of these protozoa in greater detail, it will be well to note the criteria made use of in distinguishing the *coli* and the *histolytica* cysts; those of *Giardia* and *Chilomastix* need no description. As regards the points relied upon in differentiating *coli* from *histolytica* cysts, as is well known, it is the general summation of various characters which enables a definite diagnosis to be made in almost every case; no single character considered alone will suffice for a decision. The points are:—

1. Size.
2. Nuclei: (*a*) number, (*b*) character and arrangement of the chromatin.
3. Cytoplasm.
4. Inclusions: (*a*) chromatoid bodies, (*b*) vacuoles.
5. Cyst wall.
6. Shape.

1. *Size.* The vast majority of *histolytica* cysts have a diameter between 5μ and 15μ, and of these there are said to be two chief strains met with, namely, 'small,' between 6μ and 9μ, with an average diameter of $7{\cdot}7\mu$, and the 'ordinary,' between 10μ and 14μ, with an average of $12{\cdot}6\mu$.

Coli cysts vary between wider limits, namely, 11μ to 35μ, the commonest being between 14μ and 22μ, so that difficulties under this head are only likely to arise in differentiating between a large *histolytica* and a small *coli* cyst.

2. *Nuclei*: (*a*) Number. In *histolytica* they may vary from one to four. Malins Smith states that more than half are quadrinucleate, while one-third are uninucleate. In contradistinction to this, more than four-fifths of *coli* cysts contain eight nuclei, and only about 10 per cent. are quadrinucleate, or less; occasionally a cyst with sixteen nuclei may be met with. It would appear that the consistence of the stool has some influence; thus, it is stated that in loose stools about 60 per cent. of the cysts contain eight nuclei, in semi-formed between 80 and 90 per cent., and in formed stools between 90 and 95 per cent. Binucleate cysts are found in about 7 per cent., and quadrinucleate in 3 per cent.

(*b*) Character and arrangement of the nuclear chromatin. The situation of this is, in either case, peripheral, but in *histolytica* it consists of smaller granules and is distributed fairly evenly, whereas in *coli* it is in larger masses or small blocks less evenly distributed, and therefore outlines the nucleus more definitely than is usually the case in *histolytica*.

3. *Cytoplasm.* This is of a greenish hue in a fresh specimen of *histolytica* and is not uniform in appearance, whereas in *coli* the uniformity is greater, the colour is pale and more of a greyish tint.

4. *Inclusions*: (*a*) Chromatoid bodies. These are better seen in fresh saline specimens than in preparations put up with Weigert's iodine. In *histolytica* they are found in about 30 per cent. of the cysts, are rod-shaped, with blunt, square or rounded ends; whereas they are less commonly seen in *coli*, only about one in twenty containing them, they are more irregular, are often pointed at the end, or 'splintered.' The value of chromatoid bodies in diagnosis is variable, for they may be absent from two-thirds of the cysts.

(*b*) Vacuoles. These are fairly often seen in *histolytica*, may be multiple, and usually have an ill-defined contour and stain faintly with iodine; in contradistinction the vacuoles of *coli* are rarely multiple, have a sharply defined edge, and stain more deeply with iodine.

5. *Cyst wall.* This is usually thinner in *histolytica* than in *coli*, and the latter sometimes appears to have a thin second contour; these points, however, are far from distinct, and are of minor importance as aiding diagnosis.

6. *Shape. Coli* is stated to be less frequently asymmetrical than is *histolytica*, but one comes across cases in which quite a considerable proportion of the *coli* cysts are asymmetrical; this was particularly noticed in one of the patients in my series.

When the majority of these points are in evidence there is no difficulty in diagnosis, but one may meet with cysts which have two or four nuclei, are ill-defined as to colour and uniformity of the cytoplasm (as stated by Matthews and Malins Smith), have no chromatoid bodies, no vacuoles, and not a sufficiently distinctive arrangement of the peripheral chromatin; in such cases certain diagnosis is not possible, but fortunately these are rare.

ENTAMOEBA COLI CYSTS

These were present, as already stated, in 47 per cent. of the one hundred and two cases examined; there was a slightly larger proportion found among males, viz., twenty-seven out of fifty-three (in the females twenty-one out of forty-nine). Since at least five hundred cases should be examined before any reliable inferences can be drawn as to incidence, it is very probable that further examinations would alter this preponderance. As shown in the table, it was the only one found in five cases of the males and in eight of the females; in conjunction with others it was more often met with. In some instances the infection was multiple; thus, in two of the males and one of the females there were *Ankylostoma*, *Ascaris*, *Trichiuris*, *coli*, *histolytica*, *Giardia* and *Chilomastix*, without causing any apparent abdominal or intestinal disturbance.

No age seems to be exempt; thus, the cysts were found in a boy of 9 years of age and in a man of 68 years, in a girl of 13 and a woman of 56. None were found in the five women whose ages exceeded this, probably a mere coincidence.

It is interesting to remark that the nearest approach to the proportion of *coli* infection found in this series of natives examined (namely, 47 per cent.) was noted by Matthews and Malins Smith in England among asylum patients (45·9 per cent.). For those who are acquainted with the West Indian native, the obvious inference would form a subject of acrimonious if not fruitful debate.

Mention has already been made of the irregularity of distribution of the cysts of *coli* in the faeces, resulting in the finding of several in one specimen and none in others in the same stool; but, by examining larger amounts and concentrating, as I tried to do, the effects of this irregularity have been reduced. The fact must also be borne in mind that the cysts may appear intermittently and be found in nearly all the preparations made one day, but absent on another in spite of the careful examination of many preparations. Several of the cases given in the table bear out this point. Thus, in No. 52 of the males no cysts were found until the middle of the third week of examination, and in No. 16 they were seen on the first day in conjunction with *histolytica*, but not again, although the latter was found once subsequently. Other instances of intermittency

among the males are Nos. 4, 6, 15, 18, 49. More cases of a single finding of this variety of cyst occurred among the women, namely, Nos. 18, 25, 9, 41, 27, 3, when they were seen at the first, third, fifth and sixth examinations only. In Nos. 42 and 24 they were not seen until the seventh and eighth examinations respectively, and, although there was infection in No. 22 with *coli*, *histolytica*, *Giardia* and *Chilomastix*, the first-named was found on one occasion only.

It has been stated by Dobell that 'in a series of cases in which the mean number of examinations per case is three, not more than two-thirds, and possibly not more than half, will be detected.' Taking the first three examinations in this series of cases, there were detected fourteen among the females and eighteen among the males, a total of thirty-two out of the forty-eight in whom these cysts were present—exactly two-thirds.

Matthews and Malins Smith found that six examinations give for *histolytica* about three times the number of positive results obtained by one examination (23 per cent. in place of 7·8 per cent.), and for *coli* 20·6 per cent. from one examination became 59·8 per cent. by subsequent ones.

In my series, five only of the twenty-two positive cases among the females were detected at the first examination (less than one in four), and ten of the men, giving a total of fifteen out of forty-eight in spite of the concentration methods.

ENTAMOEBA HISTOLYTICA CYSTS

The cysts of *histolytica* are usually more regularly distributed than those of *coli*, though less so than those of *Giardia*. A negative record may, as Dobell states, arise either from their having a localised distribution and the part containing them not being submitted to examination, or to their being few in number and so overlooked. He offers an explanation as to the uniformity or localisation of distribution in the site of infection; if the upper part of the large intestine is affected, the faeces here being more or less fluid the cysts are fairly evenly distributed, and when solidification of the faeces occurs lower down the cysts remain scattered through the mass, but, if the lower part is affected, the faeces are already practically solidified and the cysts from the ulcerated surface are thus more superficially distributed

and also localised to those parts of the contents which have been in contact with the infected, ulcerated surface.

There would seem to be no periodicity in the appearance of cysts of *histolytica* in the faeces. Owing to the scarcity or to the localised distribution a negative record must not be taken to mean non-infection, unless a large number of examinations are made. Three negative examinations certainly do not warrant a negative report. Thus, only three of the cases among the females were discovered in my series in the first three examinations and not a single one at the first, in spite of the concentration method, showing most emphatically the uselessness of a negative single finding. Among the males only two were found at the first examination, and only six in the first three. Of the men and women together, only nine out of fifteen were discovered in the first three examinations. At the fourth one more was found, another at the fifth, three more at the sixth, and one not until the last time of examination.

The tables show also the irregularity in the days of appearance of the cysts of *histolytica* in the faeces; thus, amongst the men they were noted at the first and seventh; first, second, eight and ninth; second, third, fourth, fifth, sixth and ninth; second, fourth and sixth; second and third only, second and sixth; and so on. Among the women on the second only; the fourth only; the fifth and ninth; the second, third and seventh; the second, fifth, sixth and seventh.

These patients were not being treated for the presence of these cysts, for none of them showed any clinical symptoms attributable thereto, and the mere presence of them does not imply amoebic dysentery either present or past, and certainly does not warrant specific treatment. The danger is more, of course, for others, for, though causing no symptoms in the host, they may nevertheless produce acute dysentery in another.

In this small series of one hundred and two cases it is seen that a larger number of *histolytica* carriers was found amongst the men than the women, in the proportion of three to two. Age appears to have no significance; thus, of the females one was aged 13, two were 28, one each at 30, 50 and 56 years. Of the men the youngest was 23, then came one at 25, one each at 29, 30, 31 and 32, two at 35 and one at 52 years; the only point which may be mentioned is that seven of the fifteen were found in patients during the third decade.

The importance of this infection with *histolytica* is great. From an examination of a large number of cases, Dobell stated that the incidence of infection does not appear to be conspicuously greater among the cases arriving at the general hospitals for treatment than among those reaching their final depôts after such treatment. It would seem, therefore, that the treatment which most of the dysenteric patients had received had not been sufficient to rid them of their infections. This refers to patients who suffer or have suffered from an attack of dysentery. Seeing that the infection is high in my series of patients who had not been abroad (*i.e.*, outside Jamaica) and who showed no clinical symptoms of intestinal mischief, there is every likelihood of greater spread now that large numbers of the contingents sent to the war from that island have returned, and that several of them suffered from dysentery in Egypt and elsewhere. Further, 'Egypt and its neighbouring lands are notorious centres of amoebic infection.' Dobell has also shown that passage through an infective area, by affording an opportunity of exposure to infection with *histolytica*, resulted in the acquisition of infection by a large number of individuals. The incidence of infection in men returning from Egypt and Gallipoli was not conspicuously higher among those who were classified as 'dysenterics' than among those invalided for other reasons. This is very applicable to the men who went from Jamaica, for many (if not most) of them served in Egypt, and some, at least, must have brought back infection with them.

As a matter of fact, the danger of spread is greater there than at home, for many of those harbouring the cysts appear to be in perfect health, are able to undertake their regular duties, associate freely with their fellowmen, and may spread the disease. Also the duration of carriage in a healthy carrier is not known, and would appear to be almost indefinitely prolonged; though there are intervals when the condition clears up, still this disappearance is only temporary. The two main safeguards against spread are a good sewerage system and abatement of the fly nuisance. Except in Kingston itself, and in parts only of the city, there is no proper sewerage system, the street gutters constituting the sewer for many. As regards the fly question, this is always a difficult problem in the tropics, and since we know that flies can take up *histolytica* cysts, pass them unchanged through their bodies and so infect food, the danger is clearly a very real one.

Wenyon and O'Connor's (1917) remarks on the fly question may be briefly quoted here:—

1. Flies readily take up encysted and other forms of protozoa into their intestines.

2. Encysted forms remain in the intestines of the fly as long as there is any faecal matter. If prevented from feeding they may retain the cysts for as long as forty-two hours; if feeding is allowed, they do not retain the cysts as long, and the flies may deposit material (and with it cysts) ingested only five minutes previously.

3. Cysts do not degenerate to any extent in the intestines of the fly, but readily pass unaltered.

GIARDIA INTESTINALIS

There is no proof that *Giardia* is pathogenic, at any rate in adults. It has been found in a considerable number of instances in this series, sometimes in a free state, sometimes encysted and in very large numbers. Its presence has been noted in thirty-six of the one hundred and two cases, or 35·29 per cent.; of these twenty-one were amongst the fifty-three males and fifteen amongst the forty-nine females. This, again, is a higher percentage than was found in cases recorded by Dobell, Wenyon and O'Connor. The first-named found 27·3 per cent. with a minimum of six examinations, but states that this was probably not more than three-fourths of the real number.

This parasite is usually found more frequently in patients suffering from diarrhoea, but it is probably nearer the truth to say that the diarrhoea or loose action is the 'cause' of the detection of the infection than *vice-versa*, that the infection is the 'cause' of the diarrhoea. Two reasons may be offered to account for the high percentage of infection in my series; firstly, that in order to ensure the procuring of specimens many of the patients were given salines, thus producing a loose action, and secondly, the concentration method allowed of the discovery of the organism in cases where they would otherwise have been so few as to be overlooked.

In reports of examinations carried out in England, it has usually been found that *Giardia* was much more common in children, so

much so that Matthews and Malins Smith suggest that this flagellate is mainly a parasite of children and that it may disappear from the intestine in course of time.

In my series it was found in all cases examined (six) below the age of 15 years, but was also present in others of 20, 56, and 60 years of age (five out of eight in the sixth decade); among the females it was found in two of the three under 15 years of age, but also in seven out of seventeen between 21 and 30 years, and in one each at 37, 48 and 56 years.

CHILOMASTIX MESNILI

Cysts of this parasite were found six times among the males and seven among the females, giving a total percentage of 12·74. In some instances they were exceedingly numerous, occurring not only in every field, but sometimes more than one in the field, the concentration method accounting in part for this. They are probably of no pathogenic significance.

Lastly, it may be mentioned that *Balantidium coli* was found twice: in a woman of 56 and a man of 22 years of age, in the latter as the only parasite detected, in the former associated with *E. coli*.

The appended tables give succinctly the chief points in connection with this investigation. The patients have been arranged in order of age for ease of reference.

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Table I.—Showing results of faecal examinations. Females, Jamaica.

B.=Balantidium coli. C.=Entamoeba coli. Cb.=Chilomastix mesnili. G.=Giardia intestinalis. H.=Entamoeba histolytica ... signifies that the stool was not obtained. —signifies negative examination.

No.	Initials	Age	Disease	Helminthiasis			Protozoa								
				Ancylostoma	Ascaris	Trichiuris	1	2	3	4	5	6	7	8	9
1	A. H.	13	Pericarditis	—	+	—	—	—	—	—	—	—	—	—	—
2	D. M.	13	Chronic Ulcer	—	—	—	*C.Cb.*	*C.G.*	—	—	*C.G.Cb.*	*C.G.Cb.*	—	—	—
3	V. Y.	13	Ulcers of Leg	+	+	+	—	—	—	—	—	*C.H.G.*	—	—	—
4	L. C.	17	Gonorrhoea	+	+	+	—	—	—	—	—	—	—	—	—
5	M. W.	18	Nephritis	—	—	+	—	*C.*	—	—	*C.*	*C.*	—	—	—
6	A. D.	19	Syphilis; Gonococcal arthritis ...	—	—	—	*C.*	—	—	—	*C.G.*	*C.G.*	—	—	—
7	M. F.	19	Pellagra	+	—	—	—	—	—	—	—	—	—	—	—
8	V. B.	19	Syphilis	—	—	—	—	—	—	—	—	—	—	—	...
9	E. R.	20	Traumatic Cataract	+	+	+	—	—	—	—	*C*	—	—	—	—
10	J. S.	20	Lymphadenitis	—	—	—	—	*C*	*C.G.*	*C.*	—	—	*C.Cb.*	*C.G.*	—
11	M.S.	21	Retroversion of Uterus	+	+	—	—	*G.*	*C.G.*	*C.G.*	—	*C.G.*	*C.G.*	*C.G.*	*C.G.*
12	L. C.	23	Syphilis	—	—	—	—	—	—	—	—	—	—	—	—
13	A. H.	24	Salpingitis	+	—	+	—	—	*C.*	—	*C.*	*C.*	...	*C.G.*	—
14	A. H.	25	Pelvic Cellulitis	+	—	—	—	—	—	—	—	—	—	—	—
15	E. G.	25	Uterine Tumour	—	—	+	—	—	*G.Cb.*	*G.*	*G.*	—	—	—	*G.*
16	E. M.	25	Syphilis	—	—	—	—	—	*G.*	—	—	—	—	—	—
17	H.M.	26	Endometritis	+	—	—	—	*G.*	—	—	—	—	—	—	...
18	V. S.	26	Yaws; Ulcer of Leg	—	+	+	*C.*	—	—	—	—	—	—	—	—
19	E. P.	27	Syphilis	—	—	—	—	—	—	—	—	—	—	—	—
20	A. R.	28	Syphilis; Gonorrhoea	—	—	—	—	—	—	—	—	—	—	—	—
21	E. N.	28	Endometritis	—	—	—	—	—	—	—	—	—	...	...	...
22	M. S.	28	Staphyloma	+	+	+	*G.*	*C.H.G.Cb.*	—	—	*G.Cb.*	*G.Cb.*	—	—	—
23	M. W.	28	Lymphadenitis	+	—	+	—	*C.H.*	—	*C.G.*	*C.H.G.*	*H.G.*	*C.H.G.Cb.*	—	—
24	A. S.	29	Ascites	+	—	—	—	—	—	—	—	—	—	*C.*	*C.*

TABLE I—*continued.*

No.	Initials	Age	Disease	Helminthiasis			Protozoa								
				Ancylostoma	Ascaris	Trichiuris	1	2	3	4	5	6	7	8	9
25	C.M.	29	Fibromyoma of Uterus	–	–	–	–	–	*C.*	–	–	–	–	–	–
26	A. G.	30	Morbus cordis	–	–	–	–	–	–	*H.*	–	–	–	–	–
27	O.D.	30	Fracture	–	–	–	–	–	...	...	–	*C.*	–	–	–
28	A. H.	32	Perimetritis	+	+	+	–	–	–	–	–	–	–	–	–
29	E. M.	32	Lumbago	–	–	–	–	–	–	–	–	–	–	–	–
30	M. S.	33	Carcinoma of Uterus	–	–	+	–	*G.*	–	–	–	–	–	–	–
31	L. W.	35	Neuritis	+	+	+	–	–	–	–	–	–	...	...	...
32	C. G.	37	Syphilis	–	–	–	*G.*	*G.*	*G.*	*G.*	*G.*	*G.*	*G.*	...	...
33	J. S.	38	Hysterectomy (for Carcinoma)...	+	–	+	–	–	–	–	–	–	–	–	–
34	A. T.	45	Spinal Injury	+	+	+	–	–	*C.*	*C.*	–	*C.*	–	*C.*	*C.*
35	M. W.	45	Cirrhosis of Liver	–	–	–	*C.*	–	–	–	*C.Cb.*	*C.Cb.*	–	–	...
36	A. W.	48	Mastitis	–	+	+	*C.*	–	–	–	–	–	–	*C.G.Cb.*	–
37	D. P.	48	Morbus Cordis	+	+	–	–	–	–	–	–	–	–	–	–
38	E. H.	50	Chronic Ulcers	–	–	–	–	–	–	–	–	–	–	–	–
39	E. S.	50	Nephritis	+	–	+	–	–	–	...	–	–	–	–	–
40	M. B.	50	Pernicious Anaemia	+	–	–	–	–	–	–	*C.H.*	–	*C.*	–	*C.H.*
41	R. B.	51	Chronic Ulcer of Leg	–	–	–	–	–	–	–	*B.C.*	–	–	–	–
42	M. T.	52	Burn of Shoulder...	–	–	+	–	–	–	–	–	–	*C.*	*C.*	*C.*
43	R. S.	52	Abscess of Leg	–	–	–	–	–	–	–	–	–	–	–	–
44	M. S.	56	Peripheral Neuritis	+	+	+	–	*H.G.*	*C.H.G.*	–	–	–	*C.H.*	*C.*	–
45	E. B.	60	Growth on Foot	+	+	+	–	–	–	–	–	–	–	–	–
46	J. R.	64	Goitre	+	+	+	–	–	–	–	–	–	–	...	...
47	M. D.	64	Varicose Ulcers of Legs	–	–	–	–	–	–	–	–	–	–	–	–
48	J. M.	70	Whitlow	–	–	–	–	–	–	–	–	–	–	–	–
49	L. R.	74	Carbuncle of Back	–	–	–	–	–	–	–	–	–	–	–	–

TABLE II—Showing results of faecal examinations. Males, Jamaica.

TABLE II.—Shewing results of faecal examinations. Males, Jamaica.

B. = *Balantidium coli.* *C.* = *Entamoeba coli.* *Cb.* = *Chilomastix mesnili.* *G.* = *Giardia intestinalis.* *H.* = *Entamoeba histolytica.* ... *signifies that the stool was not obtained.* — *signifies negative examination.*

No.	Initials	Age	Disease	Helminthiasis			Protozoa								
				Ancylostoma	Ascaris	Trichiuris	1	2	3	4	5	6	7	8	9
1	C. H.	9	Fracture	+	+	+	—	—	—	—	—	*G.*	—	*G.*	—
2	R. F.	9	Fracture	—	—	—	*G.*	*G.*	*G.*	—	—	*G.*	...	*G.*	*G.*
3	V. H.	9	Fractured Tibia	+	—	+	—	—	—	—	—	—	*C.G.*	—	—
4	C. M.	13	Hernia	—	—	—	*C.G.*	—	—	—	—	*C.G.*	—	*G.*	—
5	L. B.	13	Nephritis	—	—	—	*C.G.*	*C.G.*	*G.*	—	—	—	—	*C.G.*	*C.*
6	L. S.	15	Conjunctivitis	+	—	+	*C.G.*	—	*G.*	*C.G.*	*G.*	*G.*	*G.*	*C.G.*	*G.*
7	C. L.	17	Abscess of Leg	+	+	+	*C.*	—	—	*C.*	*C.*	—	—	—	—
8	C. D.	20	Bell's paralysis	+	+	—	—	*G.*	—	—	—	*C.G.*	*C.G.*	—	—
9	E. R.	20	Syphilis	—	—	—	—	—	—	—	—	—	—	—	—
10	C. C.	21	Fracture	—	—	—	—	—	—	—	—	—	—	—	—
11	R. B.	22	Paralysis (right arm)	—	—	—	*B.*	—	—	*B.*	*B.*	—	—	—	—
12	R. W.	22	Lacerated wound of eye ...	+	—	—	*C.G.*	*C.G.*	—	*C.G.*	*C.G.*	—	*C.G.*	*C.G.*	—
13	E. H.	23	Fracture	+	+	+	*C.H.*	*C.H.G.*	*G.*	—	*G.*	*C.G.*	—	*C.H.G.Cb.*	*C.H.G.Cb.*
14	W. L.	23	Ankylostomiasis	+	—	—	—	—	—	—	—	...	...	...	...
15	S. M.	24	Syphilis	+	—	+	—	*C.*	—	—	—	—	*C.*	—	—
16	N. S.	25	Chronic Ulcer: amputation of leg	—	+	+	*C.H.*	—	—	—	—	—	*H.*	—	—
17	D. M.	26	Laceration of eye...	—	—	—	—	—	—	—	—	—	—	—	—
18	G. J.	26	Malaria	+	—	+	—	—	—	*C.*	—	—	—	*C.*	—
19	G. S.	26	Dermatitis	+	—	—	*G.*	*G.*	*G.Cb.*	—	*G.Cb.*	*G.*	—	—	*G.*
20	P. E.	27	Hernia	—	—	—	—	*G.*	*G.*	—	—	*C.G.*	*C.G.*	*C.*	—
21	E. W.	28	Syphilis	+	—	—	—	—	—	—	—	—	—	—	—
22	C. F.	29	Ophthalmia	+	+	—	—	*C.H.*	*C.H.*	—	—	—	—	—	—
23	J. R.	29	Lymphadenitis	+	—	—	—	—	—	—	—	—	—	—	—
24	S. A.	30	Fracture	+	+	+	—	*C.H.*	—	—	—	*C.H.*	—	—	—
25	N. T.	31	Nephritis	—	—	—	—	—	—	—	—	*H.*	*H.*	—	—
26	R. W.	31	Hernia	—	—	—	*C.G.*	—	—	—	—	*C.G.*	—	*G.*	—

TABLE II—*continued.*

No.	Initials	Age	Disease	Helminthiasis			Protozoa								
				Ancylos-toma	Ascaris	Trichiuris	1	2	3	4	5	6	7	8	9
27	J. T.	32	Syphilis	+	—	—	—	—	—	—	—	—	—	—	—
28	R. C.	33	Gangrene of Foot	+	—	+	—	—	—	—	—	—	—	—	—
29	R. G.	33	Splenomegaly	—	—	—	—	*C.*	—	—	*C.*	*C.*	—	*C.G.*	*C.G.*
30	E. D.	34	Malaria	—	—	—	—	—	—	—	—	—	—	—	—
31	J. C.	35	Necrosis of bone	—	—	—	—	—	—	—	—	—	—	—	—
32	P. B.	35	Conjunctivitis (gonococcal) ...	+	+	—	—	—	—	—	—	*H.*	—	—	—
33	T. M.	35	Cataract	+	+	+	—	*H.G.*	—	*C.H.G.*	—	*C.H.G.Cb.*	—	—	—
34	J. R.	37	Fracture	+	+	—	—	—	—	—	—	—	—	—	—
35	J. F.	40	Necrosis of Toe	—	—	—	—	—	*G.*	*G.*	—	—	—	—	—
36	J. S.	40	Gonorrhoea	+	+	+	—	*C.G.*	—	*C.*	—	—	—	...	...
37	H. S.	41	Cataract	—	—	—	—	—	—	—	—	—	—	—	—
38	D. P.	44	Hernia	—	—	—	—	—	—	—	—	—	—	—	—
39	W. F.	46	Fracture (Pott's)	—	—	+	*G.*	—	—	—	—	*G.*	*G.*	*C.G.Cb.*	—
40	D. M.	50	Cataract	—	—	—	—	—	—	—	—	—	—	—	—
41	A. S.	52	Cataract	+	—	+	—	*C.H.*	*C.H.*	*C.H.*	*C.H.Cb.*	*C.H.*	—	—	*C.H.*
42	W. M.	52	Hernia	—	—	—	—	—	*G.*	—	—	—	*C.G.*	—	...
43	N. M.	55	Ulcer of Buttock	—	+	—	—	—	—	—	—	—	—	—	—
44	A. M.	56	Carbuncle	—	—	—	—	—	*C.*	*C.*	*Cb.*	—	—	*C.Cb.*	—
45	C. B.	56	Cataract	—	—	—	—	*G.* free and encysted	—	...	...	...	...	...	...
46	W. D.	56	Cataract	—	—	—	*C.*	*C.G.*	*C.G.*	...	...	...	...	...	...
47	H. C.	60	Abscess of Back	—	+	—	—	—	—	—	—	—	—	—	—
48	H. F.	60	Ophthalmia	+	+	+	*C.G.*	—	*C.G.*	*C.*	*C.*	—	—	*C.G.*	—
49	Z. J.	63	Swelling (right knee)	—	—	—	—	—	*C.*	*C.*	—	—	—	*C.*	—
50	D. C.	64	Cystitis	—	—	—	—	—	—	—	—	—	—	—	—
51	W. S.	64	Syphilis	+	—	—	—	—	—	—	—	—	—	—	...
52	A. P.	68	Cataract	—	—	+	—	—	—	—	—	—	—	*C.*	—
53	T. B.	69	Ulcer of Palate	—	—	—	—	—	—	—	—	—	—	—	—

A STUDY OF THE SIZES OF *ENTAMOEBA HISTOLYTICA* CYSTS AMONGST SYMPTOMLESS CARRIERS IN JAMAICA

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This investigation was carried out coincidently with another which was undertaken to determine the incidence of intestinal parasites amongst patients in hospital for some cause other than dysentery or other intestinal complaints. Of the various patients whose stools were examined, only those with a considerable number of cysts will be dealt with in detail; others will receive briefer mention but will be included in the total of all the cysts measured.

Malins Smith (1918) has shown that the curve obtained by measurement of one thousand cysts of *Entamoeba histolytica* from thirty cases is bimodal, between 7μ and 8μ and between 12μ and 13μ; while that for *Entamoeba coli* is unimodal, between 16μ and 17μ. He also found that cases with cysts averaging between 9μ and 10μ were very rare. He demonstrated that the two chief strains were the 'small', averaging $7{\cdot}7\mu$, and the 'ordinary', averaging $12{\cdot}6\mu$, and that in England infections with the former were rare in those who had never been out of the country.

It was his experience also that each strain persisted for a long time if left without treatment, or without being effectively treated, and that the strains did not replace each other.

Dobell and Jepps (1918) claim to have established that there are five strains of *Entamoeba histolytica* cysts, those occurring most frequently being approximately $6{\cdot}6\mu$, $8{\cdot}3\mu$, $11{\cdot}6\mu$, $13{\cdot}3\mu$ and 15μ.

'For the complete demonstration of the existence of strains in cysts of *Entamoeba histolytica* it is necessary to prove that the mean diameter of cysts from any patient is not subject to any considerable variation from day to day, but remains constant.'

As regards the question as to whether change in size of cysts in *Entamoeba coli* can occur from day to day, or rather from one day to another, there is not sufficient evidence at hand, according to Malins Smith.

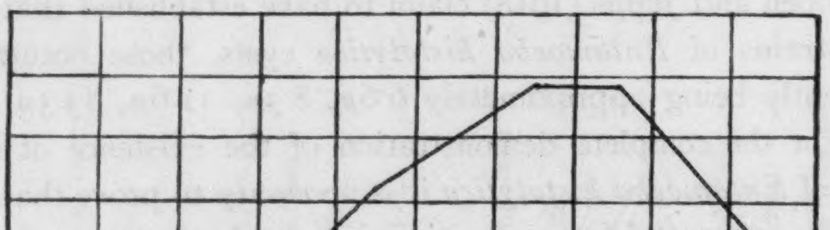
In another paper by the same author (1919), he states that samples of one hundred cysts (he is speaking of *Entamoeba histolytica*), taken on different days, often differ much more in average size than samples from the same stool, so that these differences cannot be accounted for by errors in sampling, and it has been suggested by Dobell and Jepps (*loc. cit.*) that emetine treatment may affect the size of the cysts, in that if they appear after treatment they are liable to be larger than on normal occasions. In the series dealt with below this question of the effect of emetine does not come into discussion at all, since none of the cases showed any intestinal symptoms to warrant interference, and they were not given any treatment for the eradication of the cysts.

When mixtures of 'small' and 'ordinary' strains are found it is only natural to expect that the cysts may appear in different proportions on different days, and thus there will be differences in the average size of the cysts.

The criteria relied upon for differentiation of the cysts were those stated in a previous paper on the incidence of intestinal parasites in symptomless carriers in Jamaica, namely, the size and shape of the cyst, the characters of the cyst-wall, the number of nuclei and arrangement of the nuclear chromatin, the cytoplasm and its inclusions—chromatoid bodies and vacuoles.

One of the most interesting of the cases in which cyst measurements were made regularly and in considerable numbers was that of I. E. H., male. At his first examination cysts of both *Entamoeba coli* and *E. histolytica* were found in fairly large

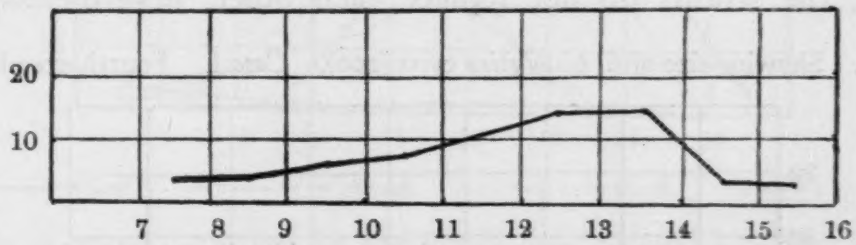
FIG. I. Showing size of *E. histolytica* cysts (72). Case I. First examination.



numbers; one hundred and thirty-two *coli* and seventy-two *histolytica* were measured. To save a long description, the curve (following the method of Matthews and Malins Smith) below gives at a glance the relative numbers present of cysts of the different sizes. To avoid making the curve too complicated, the abscissae are drawn at intervals representing 1μ, and the ordinates at intervals representing 10 units.

At the second examination, three days later, the numbers of cysts found were less, but still considerable; the *histolytica*, however, were rather more often met with, in the proportion of six to five, whereas in the previous examination the *coli* were nearly twice as numerous as the *histolytica* (this may, of course, be a mere sampling coincidence). As regards the *coli* cysts, there is not much difference to notice, except that those most frequently met with on the first day were between 16μ and 17μ, constituting nearly 50 per cent. (sixty-one out of one hundred and thirty-four), whereas on the next occasion thirteen out of fifty were between 17μ and 18μ. As regards the *histolytica* cysts, those most frequently met with, and those nearest approaching them, were practically the same as on the first occasion.

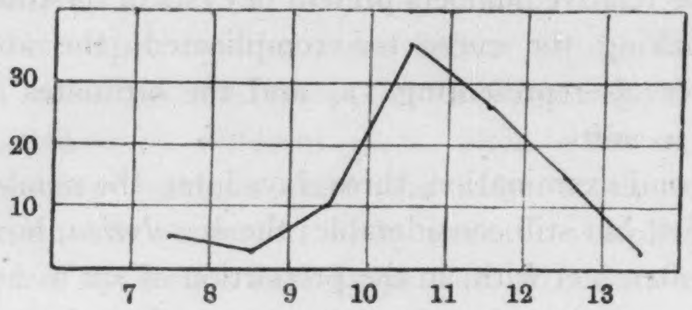
FIG. 2. Showing size of *E. histolytica* cysts (60). Case I. Second examination.



This patient then left hospital for a week to see after some private matters at home; further examinations were carried out on his return. Not only were *coli* cysts quite infrequently met with, but *histolytica* were numerous; in the course of measuring one hundred of the latter, only twenty of the former were encountered. More than one-third (seven) of the *coli* cysts were $19{\cdot}4\mu$ in diameter, and the average size of all was $18{\cdot}64\mu$; only one was found of the size (16μ to 17μ) which was most frequent at the first examination. Also, as the curve below shows, the *histolytica* cysts were distinctly smaller, though still nearer the size of the 'ordinary' strain than the 'small'. Thus, at the first examination the most frequent were

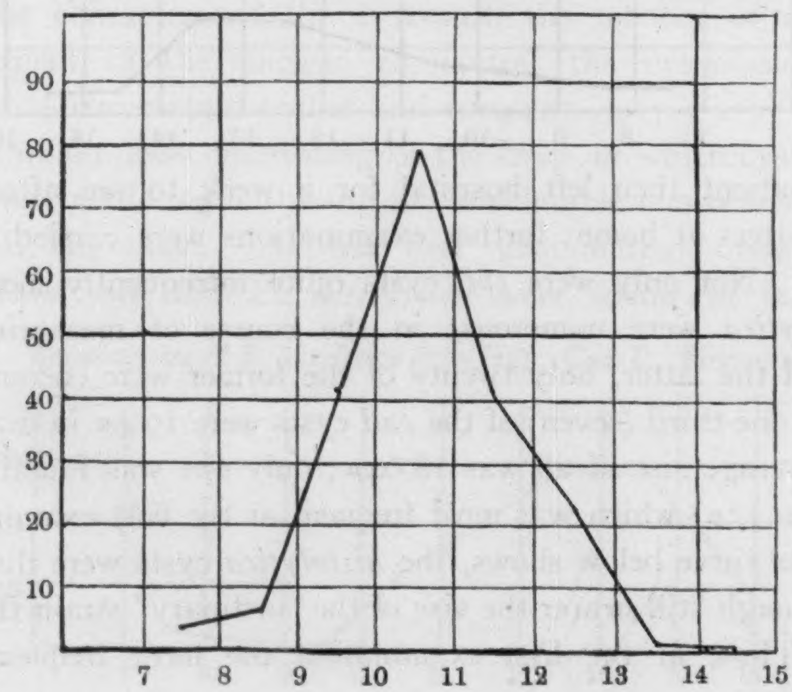
12·6μ and 13·2μ, while they were now at the third examination 10·6μ and 11·2μ.

FIG. 3. Showing size of *E. histolytica* cysts (100). Case I. Third examination.



Two days later a fourth examination was made of the stools from this patient, and again *histolytica* cysts were found in fair numbers, while *coli* cysts were conspicuous by their absence. While measuring two hundred of the former, only five of the latter were encountered. Though among the *histolytica* cysts the size most frequently met with was that of diameter 10·6μ, as before, nevertheless, as the curve shows, those a little smaller still were present in considerably greater proportion than on previous occasions. It is a matter of much regret that this patient left hospital just afterwards, so that I was not able to obtain further specimens, for though, as already stated, the strains do not replace each other, nevertheless, these

FIG. 4. Showing size of *E. histolytica* cysts (200). Case I. Fourth examination.



findings are at variance with the statement that 'the mean diameter of cysts from any patient is not subject to any considerable variation from day to day, but remains constant.'

Thus, the sizes 12·6μ and 13·2μ most frequent at the first examination became at the third examination, a week or ten days later, 10·6μ and 11·2μ; and cysts 13·2μ in size, the numbers of which (viz., twenty-seven and fifteen) were only one less than the most frequent numbers (viz., twenty-eight and sixteen) in the first and second specimens examined, had dropped at the fourth examination to only 1·5 per cent. of the cysts found.

Fig. 5, in which the curves for the different examinations are placed on one chart, the proportions of cysts of various sizes being reduced to percentages, shows well the change which occurred in the size of the cysts in the course of a fortnight or so.

Fig. 5. Showing size of *E. histolytica* cysts. Case I. Four examinations.

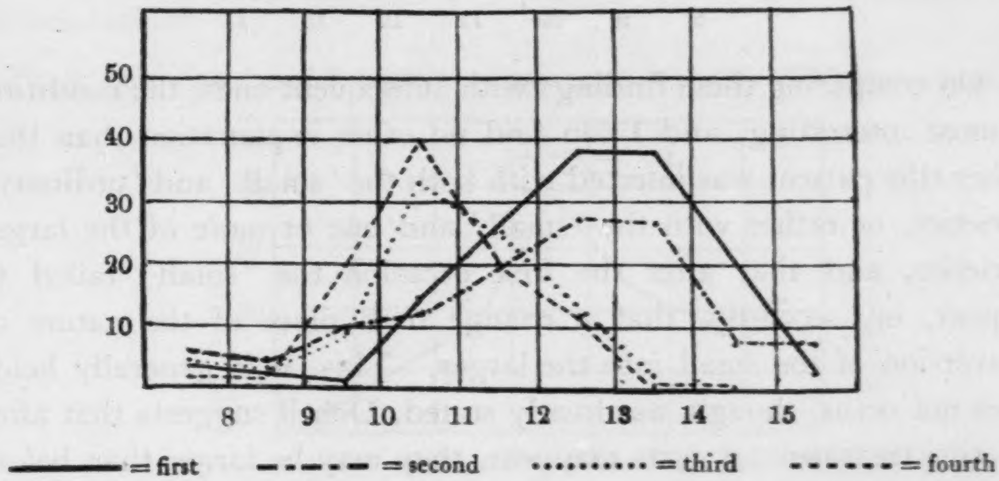
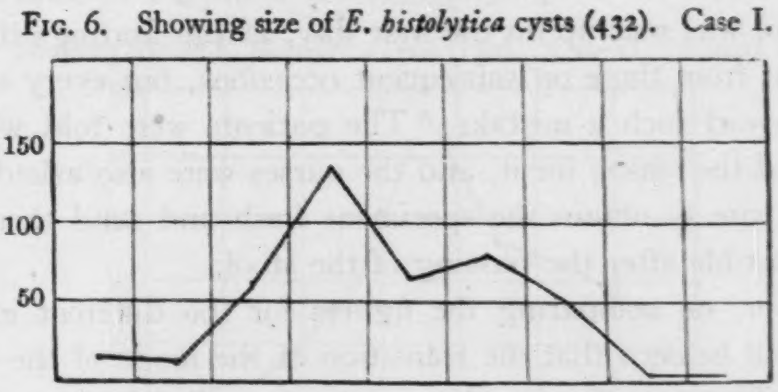


Fig. 6 gives the curve for the whole four hundred and thirty-two *histolytica* cysts measured in this case.

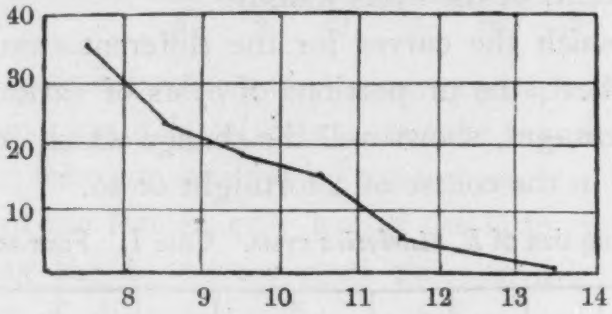
Fig. 6. Showing size of *E. histolytica* cysts (432). Case I.



II. M. W., female. Several examinations were made also of this case, and, except on one occasion, *histolytica* cysts were much more numerous than *coli* cysts. On the first occasion on which one hundred were measured, 25 per cent. were of a diameter of $7{\cdot}9\mu$; this was the size most frequently met with, while the mean for the one hundred was $8{\cdot}94\mu$, and thirty-five were between 7μ and 8μ in diameter.

Fig. 7 shows the curve of distribution on this occasion.

FIG. 7. Showing size of *E. histolytica* cysts (100). Case II. First examination.



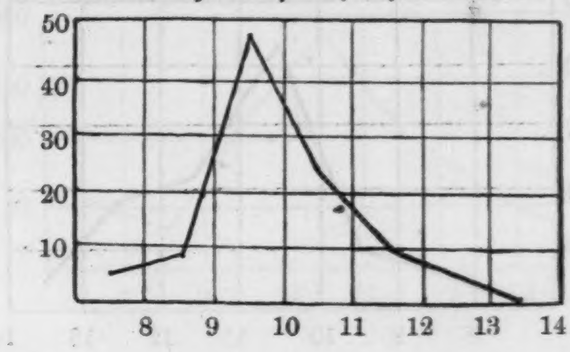
On comparing these findings with subsequent ones, the condition is most interesting, and I can find no other explanation than that either this patient was infected with both the 'small' and 'ordinary' varieties, or rather with the 'small' and one or more of the larger varieties, and that after the first occasion the 'small' failed to appear, or, secondly, that a change took place of the nature of conversion of the small into the larger. This, it is generally held, does not occur, though, as already stated, Dobell suggests that after emetine treatment, if cysts reappear, they may be larger than before treatment. In this case, as with the others, no emetine at all was given.

There is one other explanation of the findings, namely, that the wrong stool was sent up on the first day, as the findings then were so different from those on subsequent occasions, but every care was taken to avoid such a mistake. The patients were told what was wanted and the reason for it, and the nurses were also asked to take particular care to obtain the specimens fresh and send them up as soon as possible after the passing of the stool.

Moreover, on comparing the figures for the different examinations, it will be seen that the transition of the mode of the curve is gradual. Thus, in fig. 7 the greatest number had a diameter

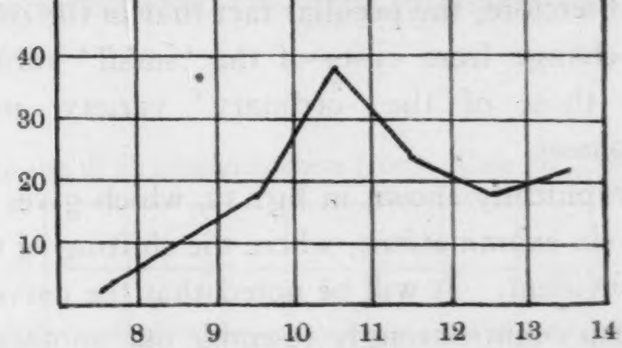
between 7μ and 8μ; after an interval of two examinations in which no *histolytica* cysts were found at all, they appeared in large numbers, those most in evidence having a diameter between 9μ and 10μ.

FIG. 8. Showing size of *E. histolytica* cysts (100). Case II. Second examination.



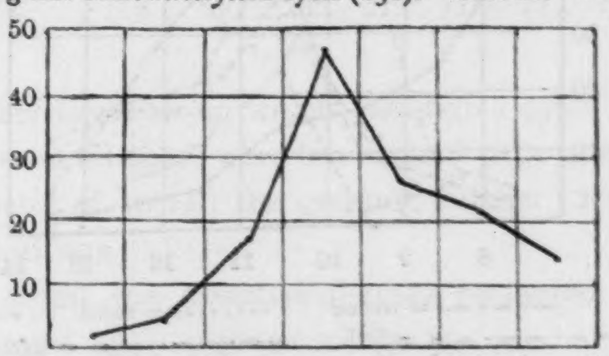
On the third occasion those most frequently encountered had an average diameter between 10μ and 11μ, and in addition there were more cysts between 13μ and 14μ than at the previous examinations.

FIG. 9. Showing size of *E. histolytica* cysts (125). Case II. Third examination.



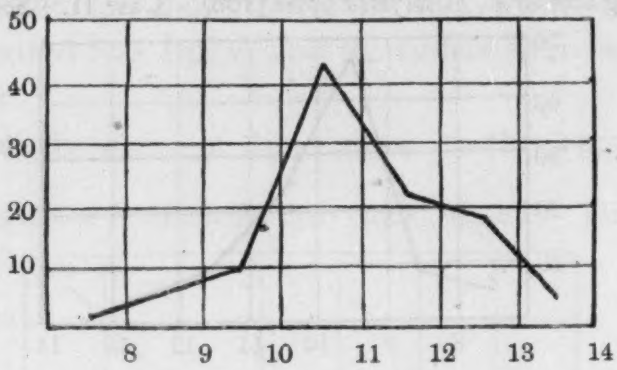
At the fourth examination, at which the cysts were numerous, those between 10μ and 11μ were again the most frequent, and even more so than at the previous examination.

FIG. 10. Showing size of *E. histolytica* cysts (130). Case II. Fourth examination.



The fifth examination showed a similar state of things as regards those between 10μ and 11μ, while those between 13μ and 14μ were becoming less again.

FIG. 11. Showing size of *E. histolytica* cysts (100). Case II. Fifth examination.



Finally, a short time before the patient left hospital the number of cysts generally was less, but though those with diameter between 10μ and 11μ comprised about 25 per cent., there was a still proportion, namely, fifteen out of forty (*i.e.*, 37 per cent.) with a diameter between 12μ and 13μ, *i.e.*, the size known as 'ordinary.'

We note, therefore, the peculiar fact that in the course of a month there was a change from cysts of the 'small' variety being most numerous to those of the 'ordinary' variety, passing through intermediate phases.

This is graphically shown in fig. 12, which gives the superposed curves of the six examinations, where the shifting of the mode to the right is very evident. It will be noted that the curves for the third, fourth and fifth counts strongly resemble one another.

FIG. 12. Showing size of *E. histolytica* cysts. Case II. Six examinations.

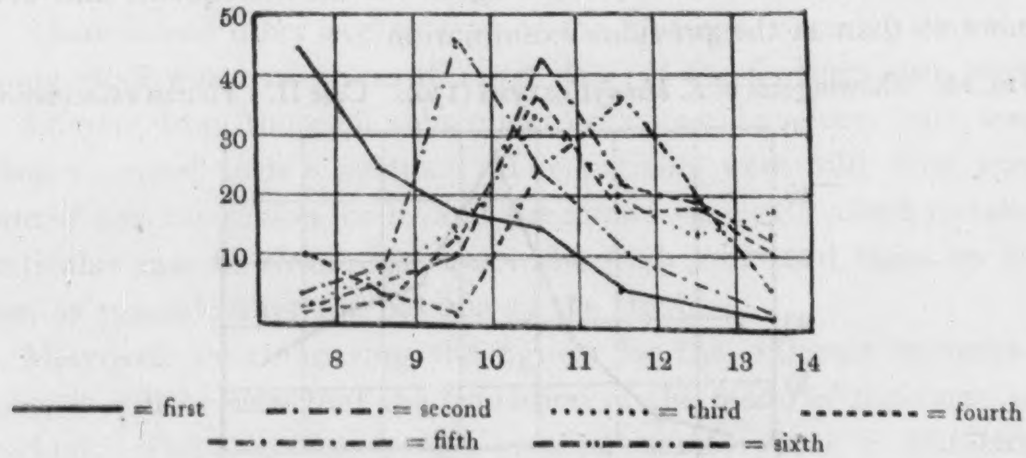
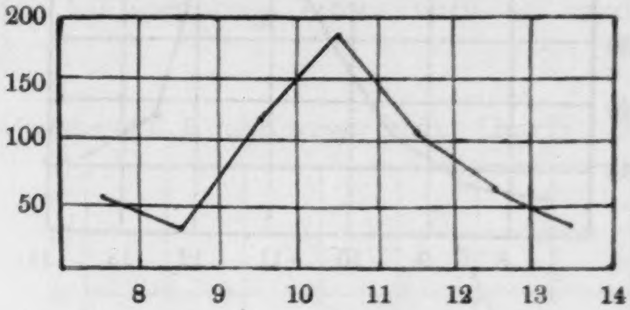


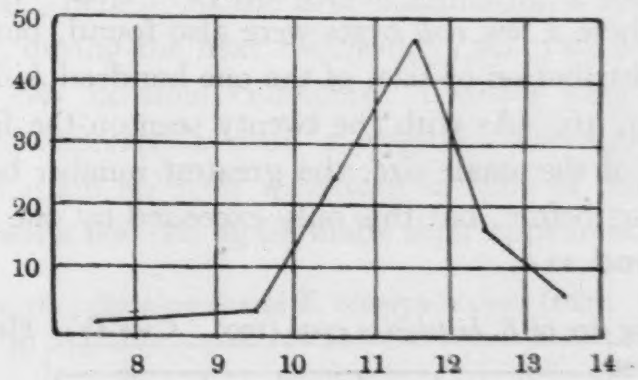
Fig. 13 gives the single curve for the whole five hundred and ninety-five cysts measured from this case.

FIG. 13. Showing size of *E. histolytica* cysts (595). Case II.



III. C. H., male. This patient's stools showed cysts of *Entamoeba histolytica* on two occasions during the three weeks, the second being five days after the first. On the first, one hundred cysts were measured, and, as the following curve shows (fig. 14), those most frequently met with had a diameter of $11{\cdot}2\mu$, while 47 per cent. were between 11μ and 12μ, and the mean for the one hundred was $11{\cdot}32\mu$.

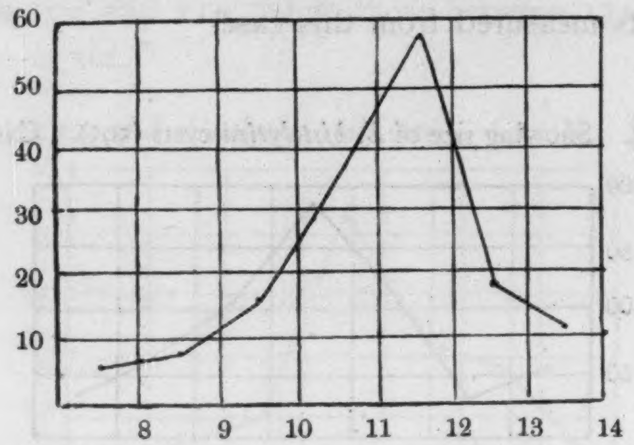
FIG. 14. Showing size of *E. histolytica* cysts (100). Case III. First examination.



On the other occasion on which *histolytica* cysts were found, out of the fifty measured there were ten each of $9{\cdot}3\mu$ and $11{\cdot}5\mu$, and an average diameter of $10{\cdot}2\mu$; the greatest number (26 per cent.) were between 9μ and 10μ.

A curve of all the *histolytica* cysts measured from this case (one hundred and fifty) is given in fig. 15.

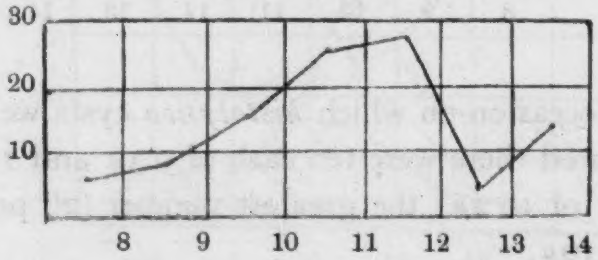
FIG. 15. Showing size of *E. histolytica* cysts (150). Case III.



IV. T. M., male. On the first occasion on which cysts were found in specimens from this patient, *histolytica* and *Giardia* only were met with, and of the former very few—twenty only in a prolonged search. Of these between one-third and a half showed asymmetry, so that the mean of the two diameters was taken as the measurement; of the twenty there were six each between 7μ and 8μ and between 8μ and 9μ, the remaining eight being between 11μ and 12μ.

For five days after this *Giardia* only was found, and then *histolytica* was encountered in considerable numbers. One was able to measure one hundred with very little searching, and during the measuring of these a few *coli* cysts were also found, but only five of them. The distribution of sizes of the one hundred *histolytica* cysts is shown in fig. 16. As with the twenty seen on the first occasion, only six were of the small size, the greatest number being between 11μ and 12μ as before, but this only exceeded by one that of those between 10μ and 11μ.

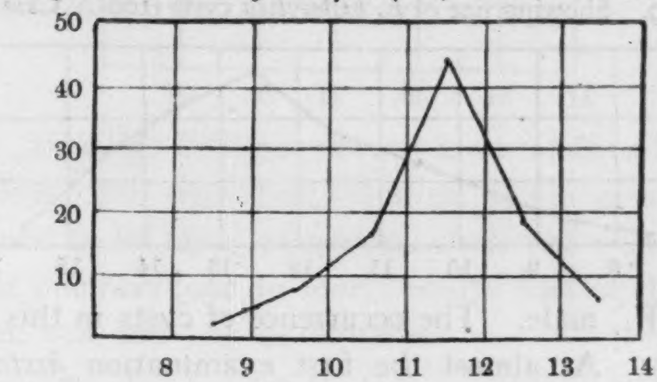
FIG. 16. Showing size of *E. histolytica* cysts (100). Case IV. First examination.



They were not found again till four days later, when practically the same condition of things was noted and cysts were encountered

in the same relative proportion, namely, six *coli* to one hundred *histolytica*. Those met with most frequently were of the same size as before, but the mean was higher, 11·6μ as against 10·8μ on the previous occasion, a difference, possibly, not more than would be accounted for by sampling errors with so small a number as one hundred.

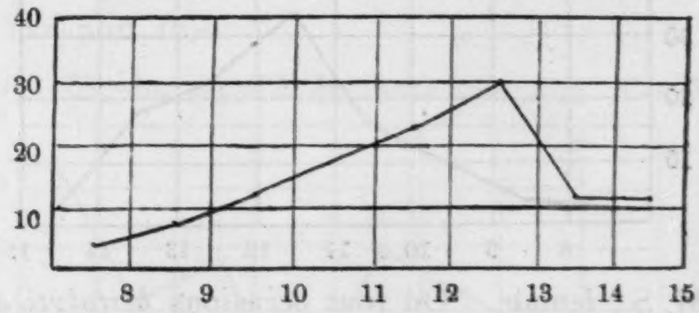
FIG. 17. Showing size of *E. histolytica* cysts (100). Case IV. Second examination.



The following five cases do not call for much individual or detailed description. In all of them *histolytica* cysts were only found occasionally, perhaps at one examination; their claim to mention consists in the fact that when they were found one hundred cysts were measured, so that a percentage of size was obtainable.

V. C. M., male. At the first examination a few *coli* cysts only were found; during the next twelve days no cysts of any kind were seen, then *coli* in small numbers. *Giardia* very numerous and one hundred *histolytica* were measured. During the succeeding twelve days again no cysts were seen in spite of repeated examinations, but then a few *coli* again made their appearance.

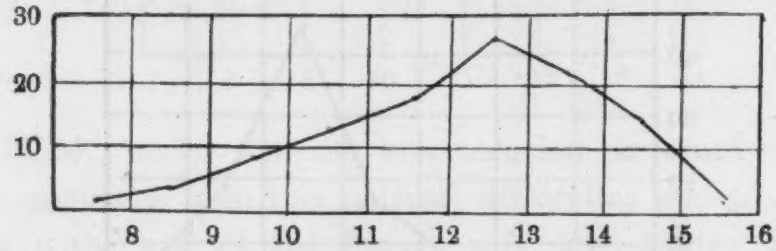
FIG. 18. Showing size of *E. histolytica* cysts (100). Case V.



VI. R. W., male. On two occasions only in three weeks were cysts found in the stools of this patient. At the first there were not

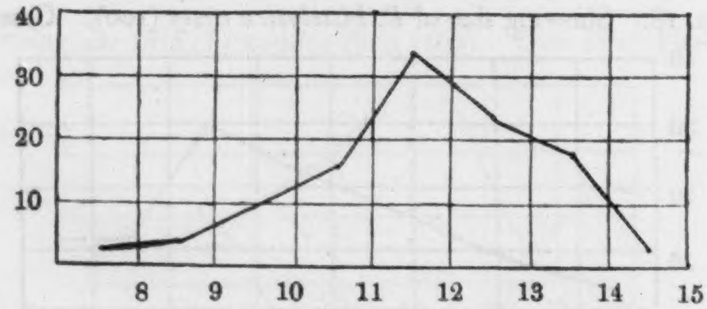
many of either form, but twenty-six *coli* were found to twelve *histolytica*. On the second occasion, eleven days later, almost the same number of *coli* were seen, but *histolytica* were more numerous, one hundred being measured. Those most frequently met with were between 12μ and 13μ, with a mean for the one hundred cysts of $12 \cdot 3\mu$. This corresponds, therefore, to the 'ordinary' type of cyst infection.

FIG. 19. Showing size of *E. histolytica* cysts (100). Case VI.



VII. W. F., male. The occurrence of cysts in this patient was very irregular. At almost the first examination *histolytica* cysts were met with in considerable numbers, and one hundred were measured. For the next four days none were seen at all; then a few, eight only, were found after a long search. They were again absent, or perhaps it were better to say undiscovered, for nine days, and then in small numbers only and with *Giardia* cysts. Two days afterwards *coli* cysts appeared for the first time since the examination was begun, though not in large numbers, and *histolytica* was present in small numbers as before, *Giardia* being numerous. A curve is given for the occasion on which one hundred cysts were measured. Those most frequently met with had a diameter of $11 \cdot 6\mu$, and the mean was $11 \cdot 69\mu$.

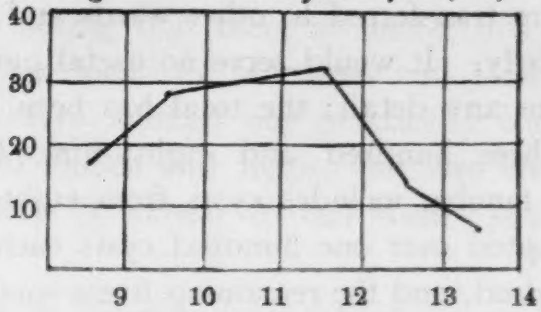
FIG. 20. Showing size of *E. histolytica* cysts (100). Case VII.



VIII. M. S., female. On four occasions *histolytica* cysts were seen in this case; the interval between two appearances was ten days in one instance. Three times out of the four a few cysts only were seen, namely, nine, six, and fifteen, but once one hundred were

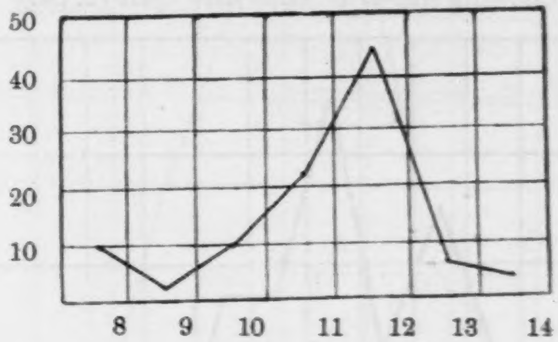
found and measured. *Coli* cysts were usually present too, but not in large numbers, and on one occasion none could be found at all.

FIG. 21. Showing size of *E. histolytica* cysts (100). Case VIII.



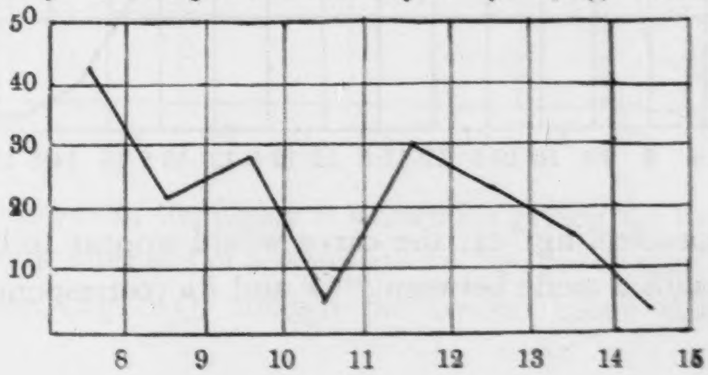
IX. M.S., female. This patient left hospital after two examinations. At one no cysts were detected at all, at the second *histolytica* cysts were found to be fairly numerous, while *coli* were present also but in smaller numbers (one to four); nearly half of the *histolytica* varied between 11 μ and 12 μ in diameter.

FIG. 22. Showing size of *E. histolytica* cysts (100). Case IX.



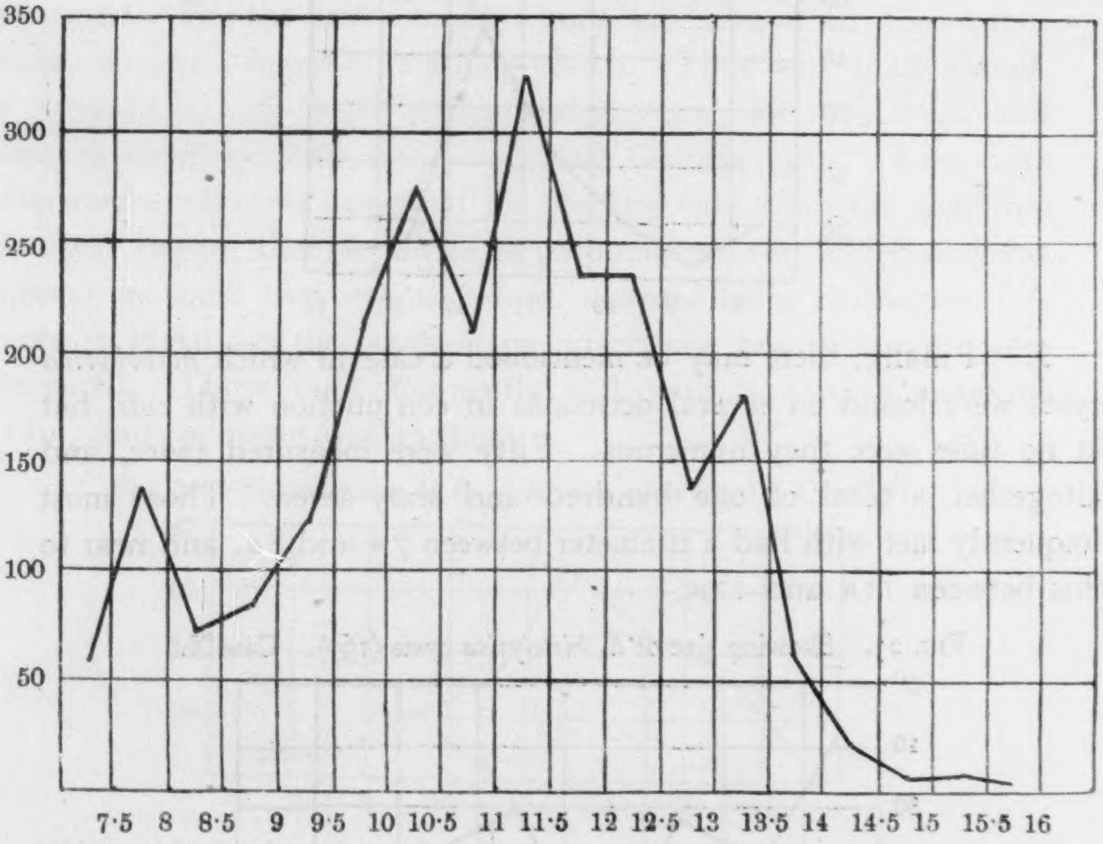
X. Finally, there may be mentioned a case in which *histolytica* cysts were found on several occasions in conjunction with *coli*, but at no time were they numerous. Fifty were measured twice, and altogether a total of one hundred and sixty-seven. Those most frequently met with had a diameter between 7 μ and 8 μ, and next to this between 11 μ and 12 μ.

FIG. 23. Showing size of *E. histolytica* cysts (167). Case X.



From three other cases between fifty and one hundred cysts were measured, while in five more a smaller number still were found. Some of these patients left hospital before the investigation could be completed, or were transferred to other wards and the stools were not sent up regularly. It would serve no useful purpose, therefore, to discuss these in any detail; the total has been included in the two thousand, three hundred and eighty-nine *histolytica* cysts measured. This number includes cysts from eighteen patients, of whom ten contributed over one hundred cysts each, three between fifty and one hundred, and the remaining five a smaller number. It may be repeated once again that none of these patients gave a history indicative of previous attack of acute dysentery (this does not preclude their having had such an attack) and none were suffering from any intestinal trouble during the time they were under investigation.

FIG. 24. Showing size of *E. histolytica* cysts (2,389).

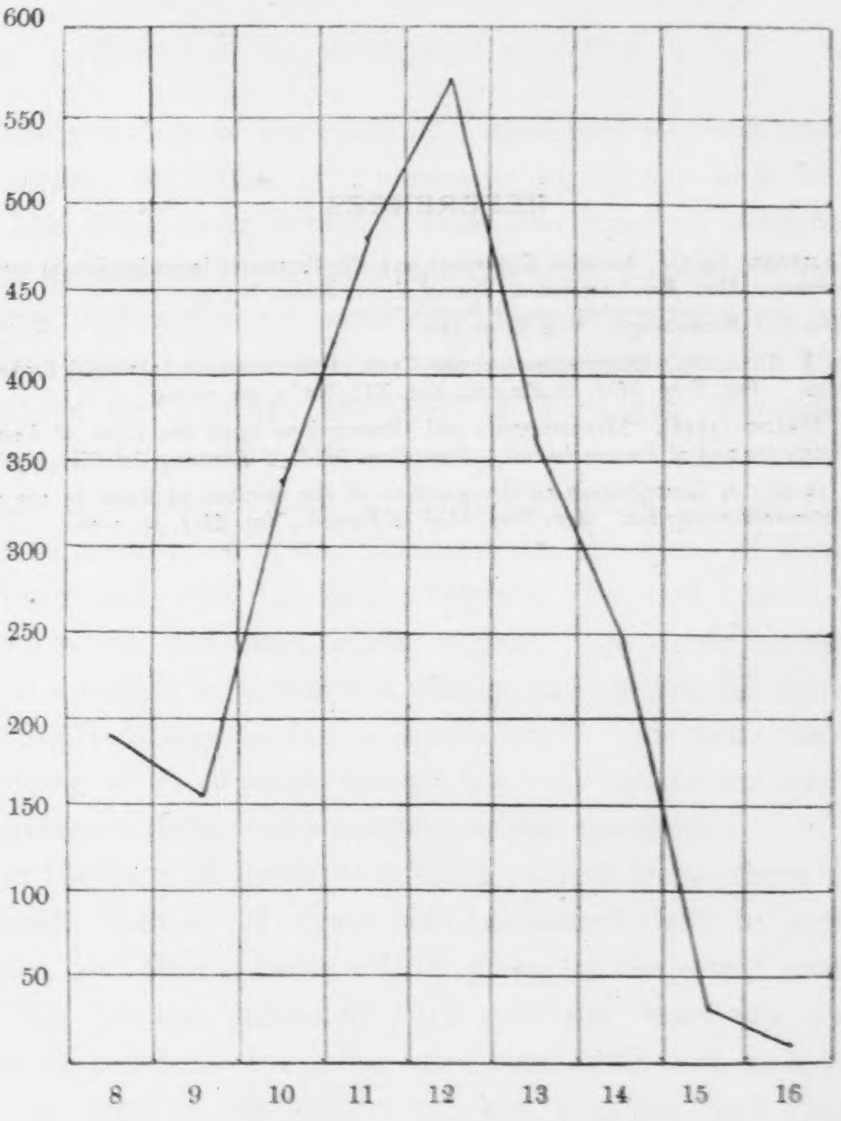


If one considers fig. 24, the curve would appear to be a multi-modal one, with a mode between $7 \cdot 5\mu$ and 8μ (corresponding to the

'small' variety) with an average diameter of 7·7μ; a second between 10μ and 10·5μ; a third between 11μ and 11·5μ; a fourth about 12μ, and a fifth between 13μ and 13·5μ.

It is worth noting that there is among this series no mode at 12·6μ as has been found by Matthews and Malins Smith at home, but there is a very marked one practically corresponding to the 11·6μ variety of Dobell and Jepps, and also one corresponding to the 13·3μ variety (I forbear to call them 'strains') of the same author.

FIG. 25. Showing size of *E. histolytica* cysts (2,389).



When, however, the figure is drawn up giving the numbers found within certain intervals of a complete 1μ, the curve then appears as a bimodal one (fig. 25), though the second mode does not occur

between 12μ and 13μ, as Malins Smith found, but between 11μ and 12μ.

The interpretation of this I cannot give, for further examinations for a prolonged period of a large number of cases would be necessary before any dogmatic statement could be brought forward. Whether the prolonged infection with the cysts of *Entamoeba histolytica* leads to their becoming reduced in size, or whether the strain in Jamaica is not the same as the 'ordinary' strain found at home, but a little smaller, is mere conjecture and not worth serious consideration with the small data at present available.

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A STUDY OF THE SIZES OF *ENTAMOEBA COLI* CYSTS AMONGST SYMPTOMLESS CARRIERS IN JAMAICA

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An investigation of the cysts of *Entamoeba coli* was undertaken simultaneously with that of *Entamoeba histolytica* and on similar lines. The stools were obtained from two series of patients, three each of male and female, on alternate days, the patients being chosen from those in hospital for some condition other than an intestinal complaint. One series was sent up for examination on Mondays, Wednesdays and Fridays, the other on Tuesdays, Thursdays and Saturdays, for a period of three weeks.

It has been stated that, in contradistinction to the curve for *Entamoeba histolytica* cysts, the curve for the cysts of *Entamoeba coli* is unimodal, with the mode between 16μ and 17μ. Another statement which has been made is that 'the evidence upon the important question as to whether change in cyst size [of *Entamoeba coli*] occurs from day to day is insufficient.' The data founded on the following series of cases, though not very extensive, may offer a little evidence to help in the solution of this question.

As in the case of *histolytica*, each patient from whose faeces a considerable number of cysts was measured will be mentioned separately, and then a curve will be given for the whole number.

I. This patient exhibited both *coli* and *histolytica* cysts in considerable numbers; the latter have been dealt with in a previous paper. As regards the *coli* cysts, one hundred and thirty-four were measured on the first occasion; among these the size most frequently met with was 16·6μ in diameter, and the mean for the whole was 17·4μ. At none of the subsequent examinations, in spite

of the fairly abundant presence of ***histolytica***, were *coli* cysts plentiful; in fact, they became less and less frequent at each examination. Thus, on the next occasion on which they were found only fifty were measured, and a prolonged search resulted in finding twenty and five respectively at the next two examinations.

FIG. 1. Showing size of *E. coli* cysts (134). Case I.

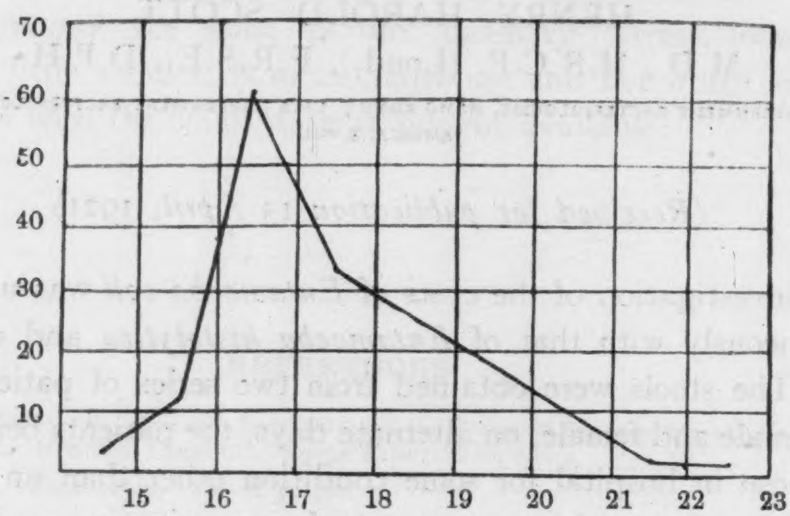
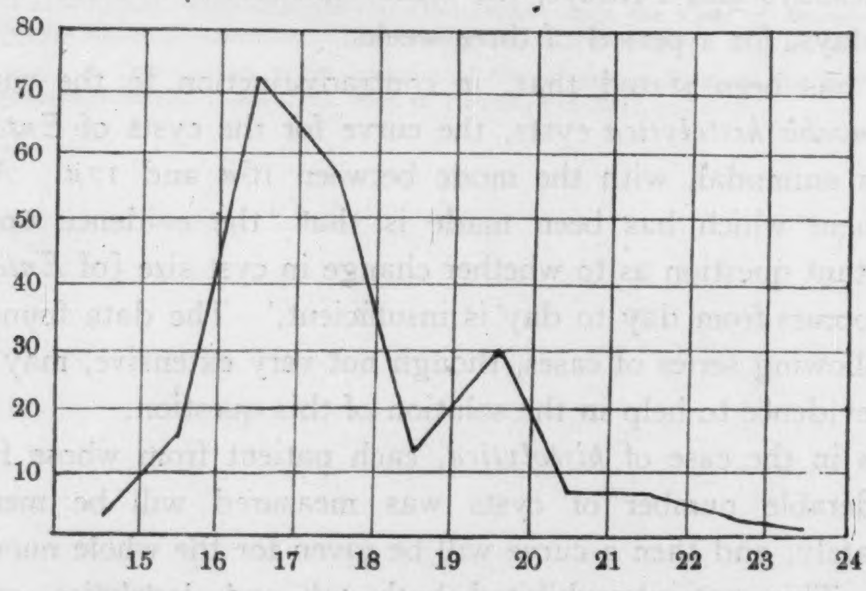


FIG. 2. Showing size of *E. coli* cysts (209). Case I.



II. The second case left hospital after two examinations had been made, in both of which *Giardia* and *coli* cysts were fairly numerous, particularly the former. On the first occasion one hundred and fifteen *coli* cysts were measured, and on the second one hundred. The curves for these and for the total are given below. At the former examination those most frequently met with had a diameter of 22·7μ, but these only exceeded those with a diameter of 19·8μ

by one, with a mean of 20·4μ; at the second, those of 19·8μ were most numerous, and the mean of the one hundred was 19·9μ.

FIG. 3. Showing size of *E. coli* cysts (115). Case II. First examination.

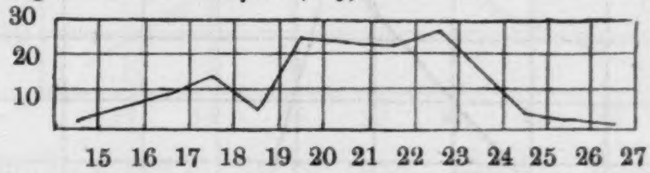


FIG. 4. Showing size of *E. coli* cysts (100). Case II. Second examination.

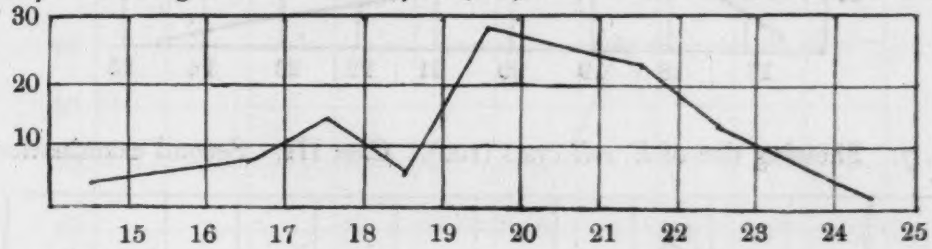
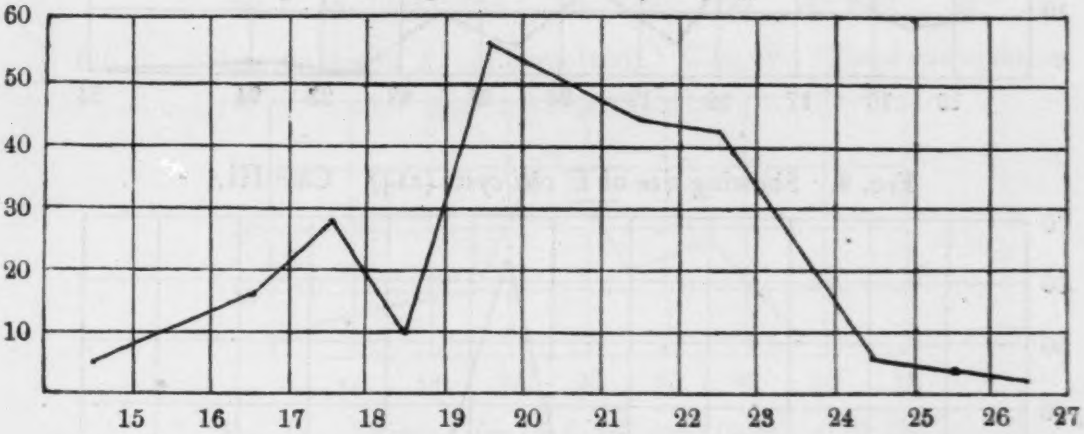


FIG. 5. Showing size of *E. coli* cysts (215). Case II.



III. At the first examination of faeces from this patient several specimens and prolonged search revealed only seven *histolytica* and three *coli* cysts. Two days later there was a different picture; *coli* cysts were many, *Giardia* and *Chilomastix* were in considerable numbers, while no *histolytica* were seen at all.

Again, after an interval of two days no *Giardia* were found, there were a few *Chilomastix*, three *histolytica* and four *coli* cysts after long search. For the next week only *Giardia* was found, and then *coli* were again numerous, as were also *Chilomastix* and *Giardia*, and a few *histolytica*.

On the first occasion, where one hundred and two cysts were measured, those most frequently met with had a diameter of 20·3μ, the mean being 20·1μ; at the last examination 17·8μ were the most frequent, and the mean was 18·17μ.

FIG. 6. Showing size of *E. coli* cysts (102). Case III. First examination.

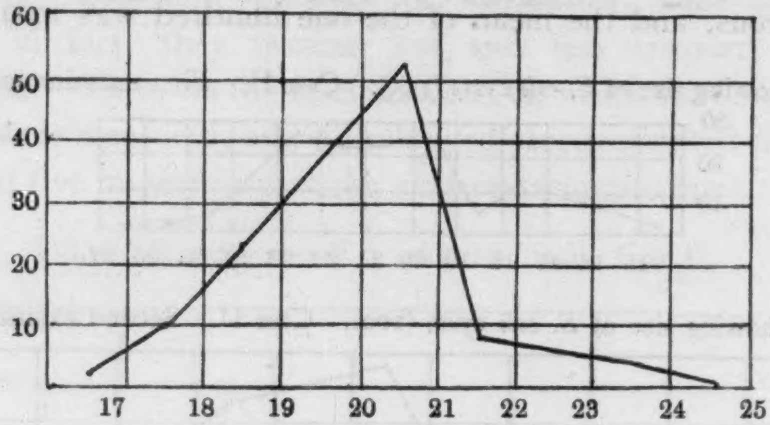


FIG. 7. Showing size of *E. coli* cysts (100). Case III. Second examination.

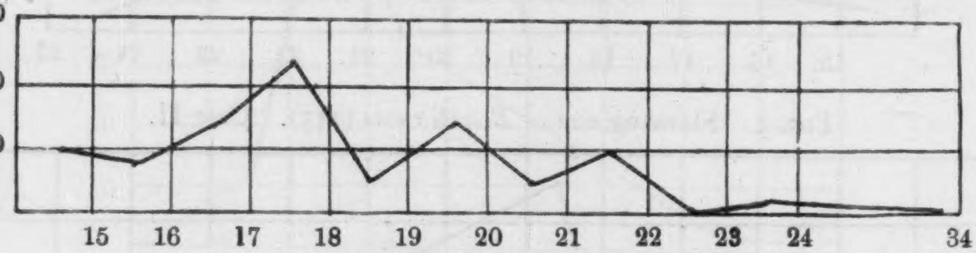
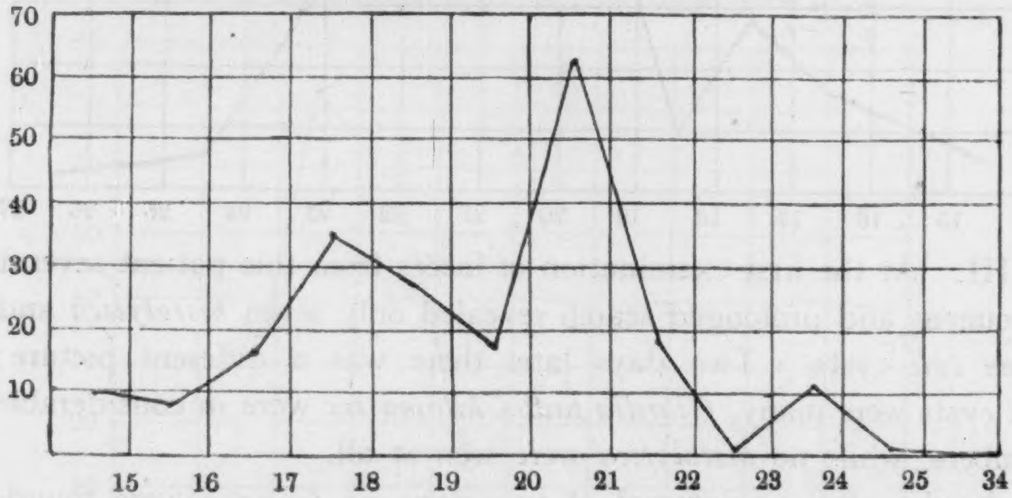


FIG. 8. Showing size of *E. coli* cysts (214). Case III.



IV. The fourth patient's stools contained *coli* cysts on several occasions, and in large numbers on some. On three of these one hundred or more were measured, and the relative proportions of the various sizes are shown in the accompanying curves. Those occurring most frequently were $20{\cdot}9\mu$, 19.8μ, and 19.8μ, respectively with corresponding means of $19{\cdot}8\mu$, $19{\cdot}2\mu$, and $19{\cdot}9\mu$, considerably larger than the usual mean of 16μ to 17μ given for *coli* cysts in general.

Fig. 9. Showing size of *E. coli* cysts (102). Case IV. First examination.

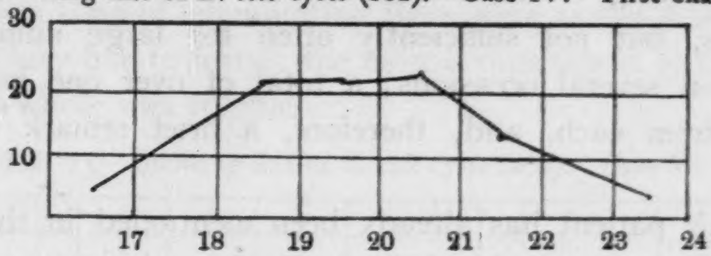


Fig 10. Showing size of *E. coli* cysts (100). Case IV. Second examination.

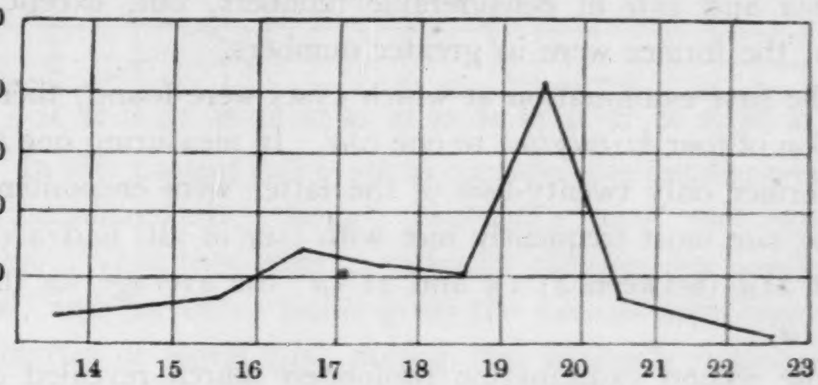
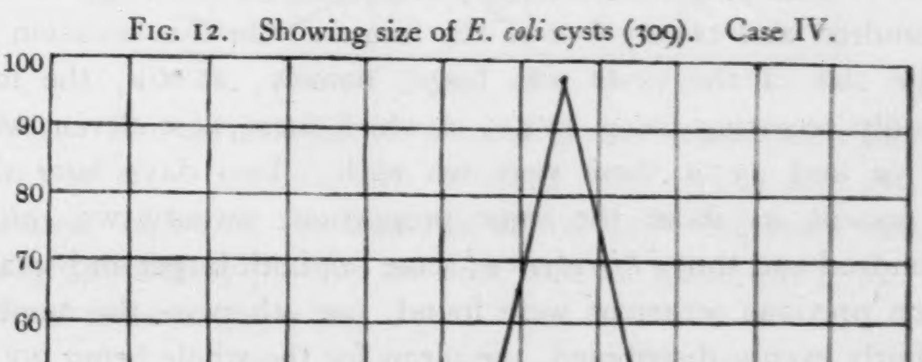


Fig 11. Showing size of *E. coli* cysts (100). Case IV. Third examination.

Fig. 12. Showing size of *E. coli* cysts (300). Case IV.



The following eleven cases exhibited *Entamoeba coli* cysts in their faeces, but not sufficiently often for large numbers to be measured on several occasions; a total of over one hundred was measured from each, and, therefore, a brief remark on them is warranted.

V. This patient has already been mentioned in the paper on the measurement of cysts of *histolytica*, as she was passing both *histolytica* and *coli* in considerable numbers, but, except on one occasion, the former were in greater numbers.

At the first examination at which cysts were found, there was a proportion of four *histolytica* to one *coli*. In measuring one hundred of the former only twenty-two of the latter were encountered. Of these the size most frequently met with (six in all) had a diameter of about 21μ (between $21 \cdot 1\mu$ and $21 \cdot 5\mu$; the average for the whole was $20 \cdot 1\mu$.

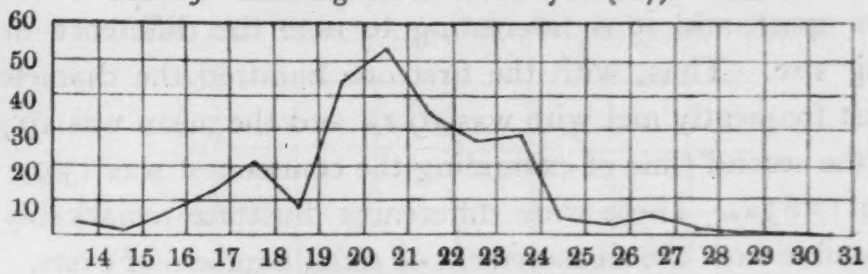
At the second examination prolonged search revealed only six *coli* cysts, varying from $19 \cdot 1\mu$ to $21 \cdot 1\mu$ in diameter, with a mean of $20 \cdot 23\mu$. On this occasion prolonged and repeated search yielded no *histolytica* cysts at all.

Two days later *histolytica* were again numerous while *coli* were very scarce, only three being encountered during the time that one hundred *histolytica* were measured. Yet again, after two more days, though *histolytica* were fairly numerous, they did not exceed the *coli* in such proportion, seventy-six of the latter being found to one hundred and twenty-five of the former. On this occasion the average size of the cysts was large, namely, $21 \cdot 06\mu$, the most commonly occurring being $22 \cdot 4\mu$, of which there were eleven, while of $20 \cdot 5\mu$ and $23 \cdot 7\mu$ there were ten each. Two days later they were present in about the same proportion, seventy-two *coli* to one hundred and thirty *histolytica*; some *coli* both larger and smaller than on previous occasions were found, but otherwise the numbers were fairly evenly distributed, the mean for the whole being $20 \cdot 1\mu$, the highest number being nineteen between 20μ and 21μ.

At the next examination *coli* were present in a proportion of one to three (thirty-three *coli* to one hundred *histolytica*). There is nothing particular to remark about them on this occasion; the most commonly occurring had a diameter of $20 \cdot 7\mu$, while only one less were $20 \cdot 1\mu$ one the one side and $22 \cdot 5\mu$ on the other; the average for the whole was $21 \cdot 47\mu$.

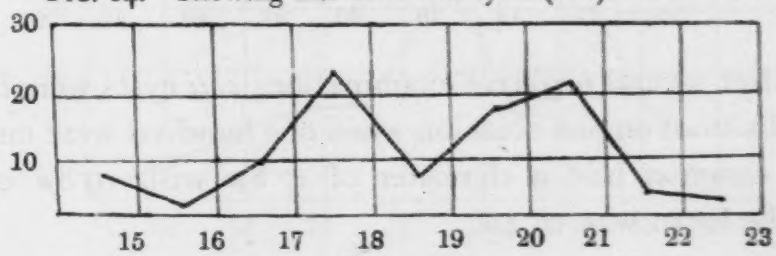
At the last time of examination there were rather more *coli* than *histolytica* (fifty-five to forty), the most common was 19·6μ, and the mean of the whole was 19·79μ.

FIG. 13. Showing size of *E. coli* cysts (267). Case V.



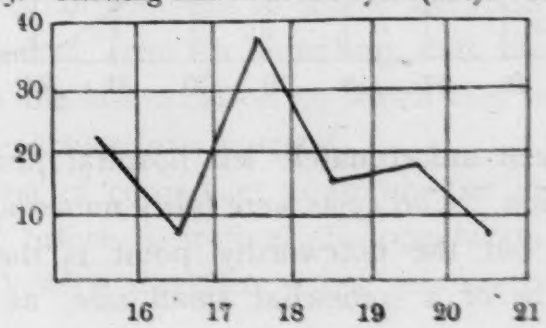
VI. In this patient *coli* cysts in considerable number were found on one occasion only, though *histolytica* were met with more frequently. When they were in sufficient numbers one hundred were measured, and the curve below gives the various sizes encountered. It is a matter of regret that during this patient's subsequent stay in hospital these cysts were not again found, because it would have been interesting to see whether this bimodal form of curve persisted, in contrast with what usually obtains in infections with *Entamoeba coli* cysts.

FIG. 14. Showing size of *E. coli* cysts (100). Case VI.



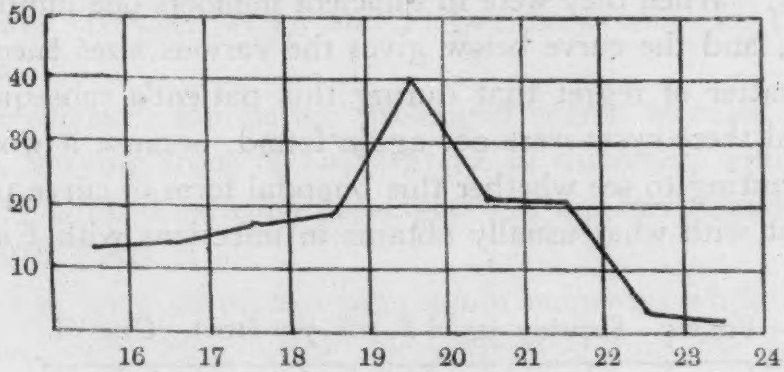
VII. This patient left hospital after one examination had been made; at this, however, one hundred and eight *coli* cysts were measured, of which the diameter of the most frequently occurring was 17·9μ, with 17·5μ only one less, and the mean was 17·8μ. The curve of these is given (fig. 15).

FIG. 15. Showing size of *E. coli* cysts (108). Case VII.



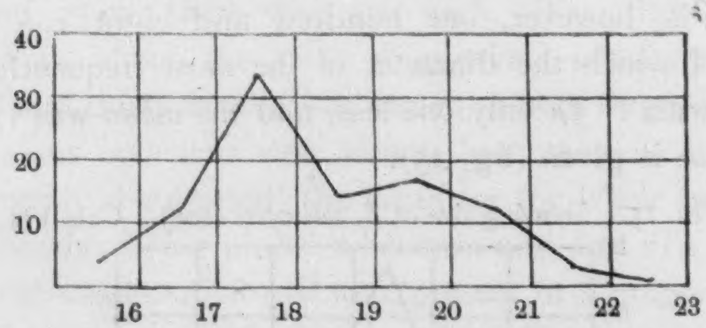
VIII. On two occasions only were *coli* cysts found in any numbers; on the first of these one hundred were measured, on the second fifty. At subsequent examinations merely three or four were found, and sometimes none at all. These two occasions were but two days apart, and it is interesting to note the difference in the prevailing size. Thus, with the first one hundred the diameter of those most frequently met with was $19{\cdot}2\mu$ and the mean was $19{\cdot}75\mu$, while at the second time of examining the commonest was $15{\cdot}9\mu$ and the mean $17{\cdot}83\mu$. These wide differences illustrate remarkably the errors possible from the measurement of small numbers of cysts. The curve for the whole one hundred and fifty is given here (fig. 16).

FIG. 16. Showing size of *E. coli* cysts (150). Case VIII.



IX. After several negative examinations *coli* cysts were found in this patient's stool on one occasion when one hundred were measured. The most common had a diameter of $17{\cdot}8\mu$ with $19{\cdot}8\mu$ only one less, and the mean was $18{\cdot}4\mu$.

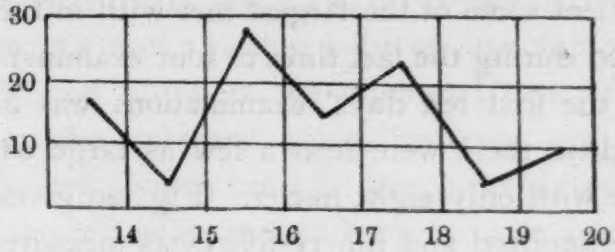
FIG. 17. Showing size of *E. coli* cysts (100). Case IX.



X. This patient unfortunately left hospital just after the first positive examination. *Coli* cysts were fairly numerous, one hundred being measured, but the noteworthy point is the tendency for the majority to be of a somewhat small size, as shown by the

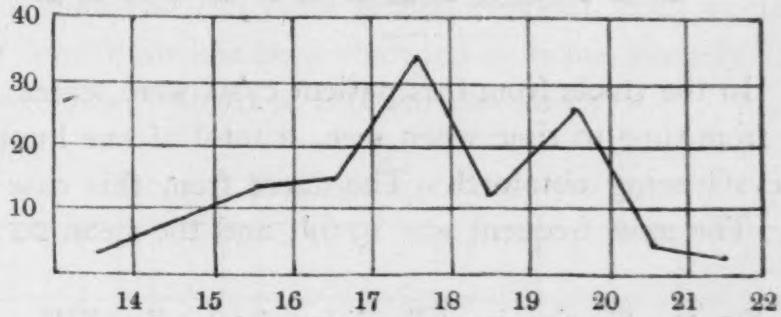
accompanying curve, though the mean for the whole works out at 16·2μ. It is a matter for regret that I was not able to follow up this patient and obtain further specimens.

FIG. 18. Showing size of *E. coli* cysts (100). Case X.



XI. Cysts were never very numerous in this case and were present intermittently, at least were only discovered intermittently. One hundred and ten cysts were measured, of which the curve is given (fig. 19).

FIG. 19. Showing size of *E. coli* cysts (110). Case XI.

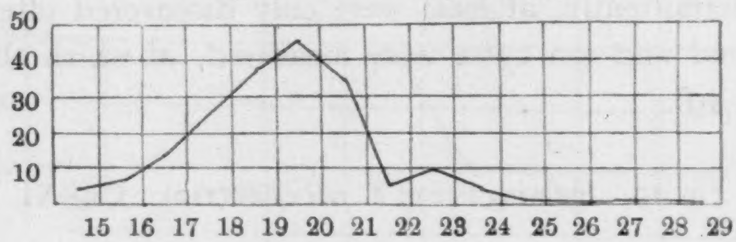


XII. *Coli* cysts were found on nearly every occasion in this case, but not in large numbers; sometimes a bare half-dozen or so after prolonged search, but on three occasions fifty were measured. On the first and second of these the diameter of cyst most frequently met with was 19·8μ, but on the third only 17·6μ. The number investigated was not sufficient to enable one to say whether this was a mere accident or error in sampling, but the smaller size was encountered on the last occasion on which they were found prior to the patient's departure from hospital.

It is a matter of conjecture as to whether immature cysts were being expelled before their final disappearance, or whether, as a corollary of Dobell's statement—that emetine-resistant *histolytica*

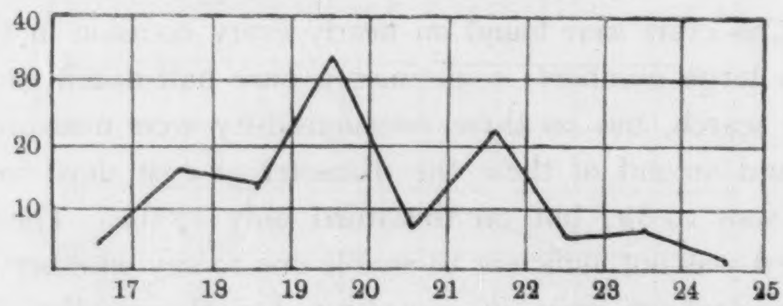
cysts, or cysts appearing after a course of emetine, are inclined to be larger than before—when the patient is getting the better of his infection, the cysts may diminish in size. One must not, of course, lose sight of the fact that *histolytica* infections are pathogenic whereas *coli* probably are not. It may also be remarked, however, that in this patient some of the largest met with in the investigation were encountered during the last three or four examinations; while the largest during the first ten days' examinations was $24{\cdot}4\mu$, towards the last eight days there were seen a few as large as $26{\cdot}3\mu$, $27{\cdot}1\mu$ and $28{\cdot}3\mu$, but with only eight nuclei. Fig. 20 gives the curve for the total of one hundred and ninety-five cysts measured in this case.

FIG. 20. Showing size of *E. coli* cysts (195). Case XII.



XIII. In the stools from this patient cysts were scarce, but were measured from time to time when seen, a total of one hundred and nineteen cysts being obtained. The curve from this case is given (fig. 21). The most frequent was $19{\cdot}6\mu$, and the mean $20{\cdot}1\mu$.

FIG. 21. Showing size of *E. coli* cysts (119). Case XIII.



XIV. From this patient only sixty *coli* cysts were measured on two occasions. The size most frequently met with had a diameter of $17{\cdot}2\mu$, and the mean was $18{\cdot}1\mu$.

XV. Cysts were found but once only in this patient's stools and

fifty were measured; twenty of them had a diameter of $17 \cdot 6\mu$, and the mean of the total worked out at $17 \cdot 73\mu$.

In all, two thousand five hundred *Entamoeba coli* cysts have been measured, and the charts below show the various sizes met with. From these curves it will be noticed that instead of a unimodal curve with mode between 16μ and 17μ, it is distinctly bimodal, with modes between 17μ and 18μ and between 19μ and 20μ.

Figs. 1, 6, and 20 show the unimodal type; fig. 2 shows in addition a smaller increase again between 19μ and 20μ; the majority of the rest show a bimodal graph, as stated above (figs. 5, 11, 19, for example); when the tendency is to be unimodal the mode is between 19μ and 20μ (figs. 12, 16, 20); in figs. 8 and 13 the majorities are between 17μ and 18μ and 20μ and 21μ, while fig. 17 is unimodal between 17μ and 18μ; fig. 21 shows yet another form.

No inference of value can be drawn from the individual curves of these cases, for the numbers in each are too small, but the graph of the whole two thousand five hundred (fig. 23) brings out the point clearly that, judging from the present findings, the graph of the sizes of *Entamoeba coli* cysts is also bimodal, both modes being at a higher level than has been recorded at home, namely 17μ to 18μ and 19μ to 20μ, instead of between 16μ and 17μ.

FIG. 22. Showing size of *E. coli* cysts (2,500).

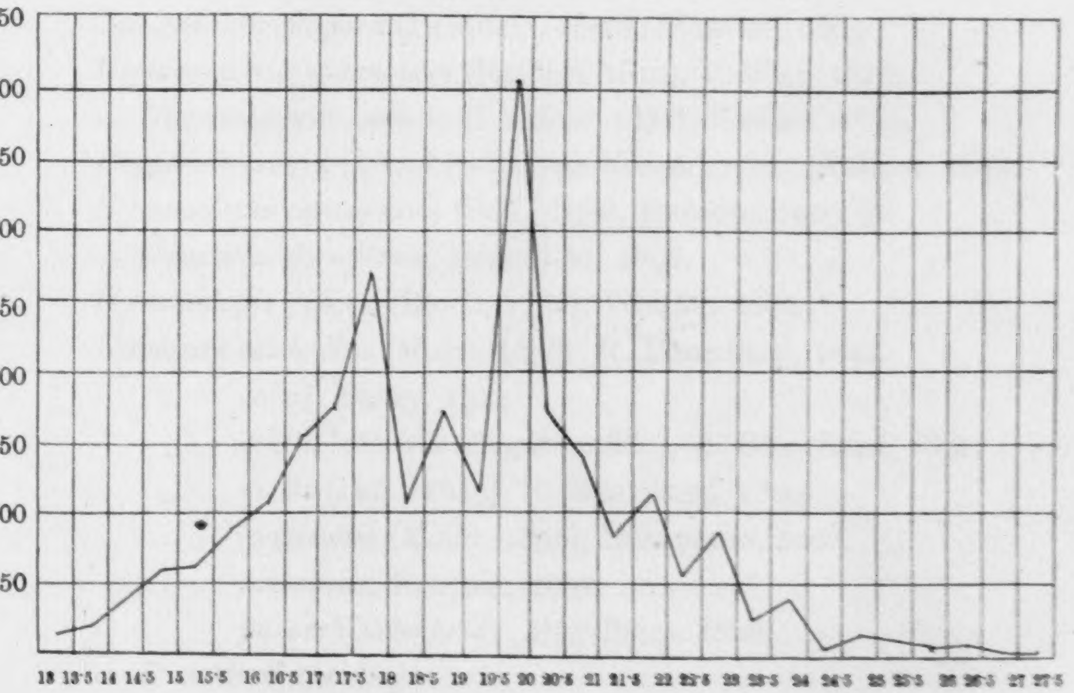
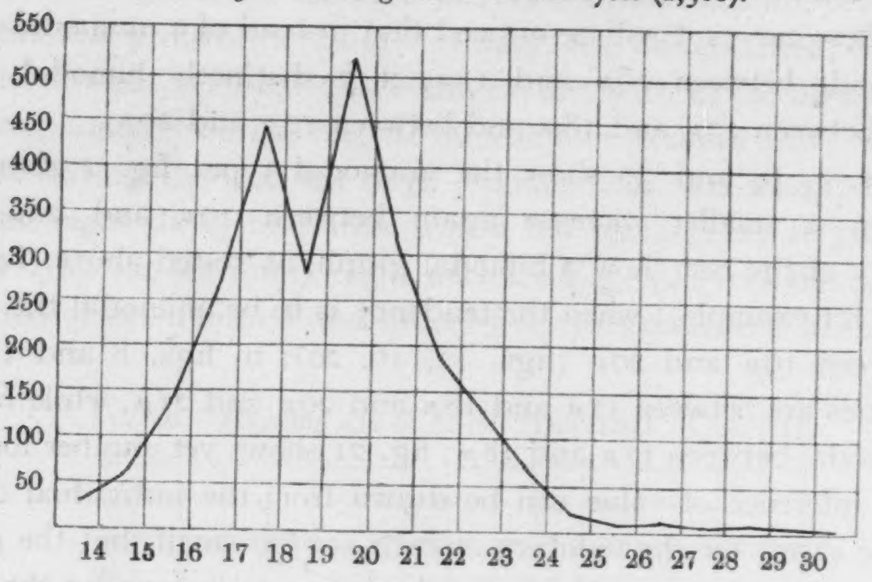


FIG. 23. Showing size of *E. coli* cysts (2,500).



CESTODES FROM INDIAN POULTRY

BY

T. SOUTHWELL

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With the exception of three species, all the *Cestoda* described below were collected by Lt.-Colonel Clayton Lane, I.M.S. (retired), from fowls, at Berhampore, Bengal, India, during 1912 and 1913. The worms were deposited by the writer in the Indian Museum and were sent for identification to the School of Tropical Medicine by Dr. Nelson Annandale, Director of the Zoological Survey of India.

The following is a complete list of *Cestoda* recorded up to the present in fowls from all parts of the world :—

Metroliasthes lucida, Ransom, 1900 ?
Hymenolepis carioca (Magalhaes, 1898), Ransom, 1902.
Choanotaenia infundibulum (Bloch, 1779), Cohn, 1899.
Bothriotaenia longicollis (Molin, 1858), Railliet, 1892 (recorded once only).
Cotugnia digonopora (Pasquale, 1890), Diamare, 1893.
Dicranotaenia sphenoides (Railliet, 1892), Railliet, 1896.
= *Dicranotaenia cuneata* (Linstow, 1872), Railliet, 1893.
Drepanidotaenia infundibuliformis (Goeze, 1782), Railliet, 1893.
Hymenolepis cantaniana (Pol., 1860), Ransom, 1909.
= *Davainea oligophora*, Magalhaes, 1898.
Hymenolepis villosa (Bloch, 1782), Wolffh., 1899.
Davainea cesticillus (Molin, 1858), R. Blanchard, 1891.
,, *cohni*, Baczy, 1914.
,, *echinobothrida* (Mégnin, 1880), R. Blanchard, 1891.
,, *exilis* (Duj., 1845), R. Blanchard, 1899.
,, *longicollis* (Molin, 1858), Führmann, 1908.
,, *mutabilis*, Reuther, 1901.
,, *paraechinobothrida*, Magalhaes, 1898.
= *D. echinobothrida* ?

Davainea penetrans, Baczy, 1914.

,, *proglottina* (Davaine, 1860), R. Blanchard, 1891.

= *D. dubinis*, Meggitt, 1916 ?

,, *proglottina dublanensis* (Kowl., 1894), Führmann, 1905.

,, *tetragona* (Molin, 1858), R. Blanchard, 1891.

,, *urogalli* (Modeer, 1790), R. Blanchard, 1891.

,, *varians*, Sweet, 1910.

,, *vigintivasus*, Skriab., 1914.

,, *volzi*, Führmann, 1905.

Fimbriaria fasciolaris (Pallas, 1781), Wolffh., 1899.

= *F. malleus* (Goeze, 1782), Froel., 1802.

= *F. mitra*, Froel., 1802.

Führmann (1920) has recently split up the old genus *Davainea* (Blanchard) into four genera, viz. :—

Davainea, Blanchard. Type *D. proglottina*, Davaine.

Davainoides, Führmann. Type *D. vigintivasus*, Sk., and *D. polycalceola*, Jan.

Houttuynia, Führmann. Type *D. struthionis* (Houtt.).

Raillietina, n.nom.

The latter genus he splits up into four sub-genera, as under :—

Paroniella, n.s.g. Type *D. longispina*.

Ransomia, n.s.g. Type *D. tetragona* (Molin).

Skrjabinia, n.s.g. Type *D. cesticillus* (Molin).

Johnstonia, n.s.g. Type *D. echinobothrida* (Még.).

Führmann removes his genus *Ophryocotyloides* from the sub-family *Davaininae* and places it in the sub-family *Ophryocotylinae*, Führmann.

Meggitt (1921), in his paper on tapeworms from the ostrich, gives a key to all the known species of *Davainea*.

The collection dealt with in this paper comprises the following species :—

Metroliasthes lucida, Ransom, 1900.

Cotugnia digonopora (Pasquale, 1890), Diamare, 1893.

Dicranotaenia sphenoides (Railliet, 1892), Railliet, 1896.

Davainea cesticillus (Molin, 1858), Blanchard, 1891.

,, *echinobothrida* (Mégnin, 1880), Blanchard, 1891.

,, *tetragona* (Molin, 1858), Blanchard, 1891.

Monopylidium gallinarum, n.sp.

Diorchis, sp. (*americana ?* Ransom, 1909).

Metroliasthes lucida, Ransom, 1900

Numerous specimens from a domestic fowl, *Gallus gallus domesticus*, Angul, Orissa, India: collected by the author in 1912. Numbered Z.E.V. $\frac{6179}{7}$ in the collections of the Indian Museum.

There appears to be some doubt whether this species has been previously obtained from fowls or not.

Cotugnia digonopora (Pasquale, 1890), Diamare, 1893

1. Four specimens from a domestic fowl, Berhampore, Bengal, collected by Lt.-Colonel Clayton Lane, I.M.S.
2. Two specimens as above; collected on 29.5.13.
3. Three specimens as above, 1912.

Dicranotaenia sphenoides (Railliet, 1892), Railliet, 1896
= *D. cuneata* (von Linstow, 1872), Railliet, 1893

Five specimens from a domestic fowl, Berhampore, Bengal, collected by Lt.-Colonel Clayton Lane, I.M.S., in November, 1912.

Davainea cesticillus (Molin, 1858), R. Blanchard, 1891

1. Five specimens from a domestic fowl, Berhampore, Bengal, collected by Lt.-Colonel Clayton Lane, I.M.S., 1912.
2. One specimen from *Gallus sonnerata* (Zoological Gardens, Calcutta) collected by the author on March 3rd, 1917.

Davainea echinobothrida (Mégnin, 1880), R. Blanchard, 1891

1. Three specimens from two domestic fowls, Berhampore, Bengal, collected by Lt.-Colonel Clayton Lane, I.M.S., 1912.
2. Numerous specimens (about 50) from a jungle fowl (*Gallus bankiva*), Berhampore, Bengal, collected by Lt.-Colonel Clayton Lane, I.M.S. Numbered Z.E.V. $\frac{6177}{7}$ in the collections of the Indian Museum.
3. Three specimens from *Gallus ferrigineus*, Zoological Gardens, Calcutta, collected by the author on May 27th, 1915.

Davainea tetragona (Molin, 1858), R. Blanchard, 1891

1. A total of twenty-four specimens were collected from fowls on seven different occasions, in Berhampore, Bengal, by Lt.-Colonel Clayton Lane, I.M.S., in 1912.

The two preceding species are very closely related and Stiles considers them to be identical. *T. tetragona*, however, does not, it is stated, produce

the pathological effects which result from the presence of *T. echinobothrida*, viz., nodular disease.

Ransom, however, points out that *D. echinobothrida* is a larger form than *D. tetragona*, possessing a larger head and rostellum, and larger suckers, hooks, and cirrus pouch ; the hooks are also more numerous in *D. echinobothrida* than in *D. tetragona*. In mature forms these characters appear to us sufficient to distinguish between the species.

Meggitt (1921) states that *T. tetragona* (Mol.) possesses 'unilateral genital pores and *D. echinobothrida* (Még.) alternating pores in the adult form and unilateral pores in the young. The two species are closely related and no classification can be regarded as satisfactory which separates them. A character upon which a classification may perhaps be finally based is the behaviour of the uterus and the origin of egg capsules.'

Führmann (1920) considers them distinct, his opinion being based on the pores being unilateral in one and irregularly alternate in the other. In this opinion we concur.

The following worms have not hitherto been described from fowls :—

Monopylidium gallinarum, n.sp.

Two specimens from a domestic fowl, Berhampore, Bengal, India, collected by Lt.-Colonel Clayton Lane, I.M.S., in 1912.

External Anatomy. The worms measured about 21 mm. long, and the greatest breadth was 2·5 mm. All the segments were much broader than long, even the posterior ones being shallow. The number of segments was about 130.

The head. The head is prominent and measures about 300μ long and 500μ broad ; in both specimens the rostellum was retracted and appeared as a small, bluntly-pointed projection, armed with about 120 hooks, each measuring about 90μ, and arranged in 2 rows. The suckers are large, conspicuous, and unarmed. There is no neck.

Internal Anatomy (fig. 1). The outer longitudinal muscular layer consists of a large number of separate dorsal and ventral strands. The lateral water vessels are large and clearly seen, both in the entire worm and in sections.

Genitalia. As only two worms were available, it was found impossible to do more than work out the gross details of the anatomy.

Male genitalia. There are about 30 globular testes, each measuring about 35μ, and these lie for the most part on each side of the ovary, although a few lie in front of it.

Vas deferens. The cirrus pouch is large and muscular, and the genital atrium runs anteriorly.

Female genitalia. The ovary is situated in the middle of the segment, slightly posterior, and median to, the receptaculum seminis. It measures about 225μ broad and 60μ long.

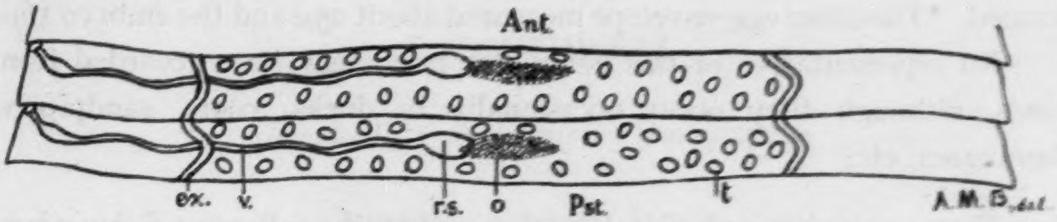

FIG. 1. *Monopylidium gallinarum*, n.sp., horizontal section. *Ant.*, anterior; *e.x.*, excretory vessel; *o.*, ovary; *Pst.*, posterior; *r.s.*, receptaculum seminis; *t.*, testes; *v.*, vagina. × 50.

Vagina. The receptaculum seminis measures about 45μ by 15μ, and lies on the pore side of the ovary.

The genital pores are unilateral and occur at the extreme anterior corner of the segment. The eggs lie in capsules, each capsule containing from five to nine. The outer egg-envelope measures about 35μ and the oncospheres about 25μ.

DIAGNOSIS. The number and size of the hooks, the position of the genital pore, the fact that all the segments are much broader than long, and the occurrence of numerous eggs in each capsule, differentiate this worm from any other species of the genus *Monopylidium*.

Johnston (1911) discusses the relationship between the genera *Monopylidium* and *Choanotaenia*.

We consider our species to be new and have therefore named it *M. gallinarum*.

Diorchis sp. (*americana* ? Ransom, 1909)

Several specimens from a hen, Calcutta, Bengal, India, collected by the author in 1915.

The only points in which our specimens differed from *D. americana*, Ransom, were as follows :—

	Length	Breadth	Rostellar hooks	Hooks on suckers
Our specimens	16 mm.	0·4 mm.	absent	absent
D. americana	20-25 mm.	0·6 mm.	Ten present	present

Two heads only were found amongst our specimens, and in both cases the rostellar hooks were absent, although fragments were to be seen. In spite of careful examination, no hooks were seen on the suckers; possibly they had worn off.

The uterus contained many eggs, but the oncospheres were not fully formed. The outer egg-envelope measured about 25μ and the embryo 16μ.

No representative of this genus has previously been recorded from fowls, although they occur occasionally in ducks, coots, sandpipers, flamingoes, etc.

The opportunity is here taken of recording the following *Echinorhynchid*, also obtained from an Indian Jungle fowl:—

Heteroplus grandis (Van Cleave, 1916), Van Cleave, 1918
= *Mediorhynchus grandis*, Van Cleave, 1916

Two females only from the intestine of *Gallus sonnerati* (South Indian Jungle fowl), Zoological Gardens, Calcutta, collected by the author on April 17th, 1917.

The type species was described from *Quiscalus quiscula* (the purple grackle) and has since been recorded by the same writer from *Sturnella magna* (the meadow lark) and *Corvus brachyrhynchus* (the crow).

Our specimens agree in detail with Van Cleave's account of this species except in size. The females described by Van Cleave measured 27 mm. to 35 mm. long, and the greatest breadth was 1·4 mm. Both our specimens measure 80 mm. long, and have a maximum breadth of 3·5 mm.

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CESTODES FROM AFRICAN RATS

BY

T. SOUTHWELL

(*Received for publication* 3 *June*, 1921)

1. *Davainea celebensis*, Janicki, 1902

Four specimens and some fragments were collected from a rat, *Mus rattus*, by Dr. J. W. S. Macfie, at Accra, March 26th, 1921.

This species was first obtained from *Mus meyeri* in the Celebes, and Janicki, in his account of its anatomy, says nothing about the head. We therefore give the following description :—

The head measures about 150μ long and 650μ broad. The suckers are about 170μ in diameter and are unarmed. The rostellum is small, measuring about 70μ in diameter, and is armed with a single row of 60 hammer-shaped hooks measuring about 12μ.

The neck is about 3 mm. long.

Führmann has recently split up the genus *Davainea* into four genera, one of which (i.e., *Raillietina*, nom.nov.) he has further divided into four sub-genera. Of these sub-genera, our species falls under *Ransomia*, and the worm is accordingly named *Ransomia celebensis* (Janicki).

2. *Zschokkeella guineensis* (Graham), 1909
=*Thysanosoma gambianum*, Beddard, 1911
=*Thysanotaenia gambiana*, Beddard, 1911
=*Zschokkeella gambiana*, Beddard, 1912.

Graham, in the 'Report on Plague in the Gold Coast in 1908,' was apparently the first to refer to this species; he named it *Davainea* (*Guineensis*, sp.nov.) [sic].

Beddard, describing in 1911 the same worm from the same host, and also from the same area, was apparently unaware of Graham's paper and gave it the name *Thysanosoma gambiana ;* later in the year he changed the name to *Thysanotaenia gambiana*, and in 1912 to *Zschokkeella gambiana*. According to the rules of nomenclature this worm now becomes *Zschokkeella guineensis* (Graham), Beddard, 1912.

In our collection we have about 600 specimens from the following sources :—

(1) From pouched rat, *Cricetomys gambianus*, Accra, December, 1914, and February, 1915. Collected by Dr. J. W. S. Macfie.

(2) From *Mus rattus* and *Mus decumanus*, Accra. No date. Collected by Dr. J. W. S. Macfie.

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A NEW SPECIES OF *CESTODA* FROM A CORMORANT

BY

T. SOUTHWELL

(*Received for publication* 3 *June*, 1921)

Dilepis kempi, n.sp.

Four specimens from the little cormorant, *Phalacrocorax pygmaeus* (= *P. javanicus*), North Lohtak Lake, Manipur, Assam, 14.2.20. Station I, Manipur Survey. Collected by Dr. S. W. Kemp, Zoological Survey of India.

External Anatomy. The largest worm measures 5 cms. long, and the greatest breadth is about 1 mm. It contains over 500 segments, all of which are broader than long ; the posterior segments measure about 900μ broad and 400μ long.

The genital pores are unilateral and situated in the anterior half of the segment.

Head. The head is about 220μ long and 400μ broad. The rostellum is about 170μ long and about 160μ broad ; it is armed with twenty hooks arranged in two rows. The posterior row of hooks curve backwards strongly and measure about 135μ ; the anterior row are not so strongly curved and measure about 175μ. The diameter of the suckers is about 100μ.

Neck. There is no neck.

Internal Anatomy. *Male genitalia*. There are three testes situated in the median field. They measure about 140μ by 70μ, their long diameter being dorso-ventral. The *vas deferens* arises somewhat ventral and, curving dorsally, runs in a lateral direction, dorsal to the water vessel and ventral to the vagina, to the pore (figs. 1 and 2). The cirrus pouch is small and insignificant.

Female genitalia. The ovary is situated in the median anterior field. It consists of two irregularly-shaped wings, each measuring about 160μ broad.

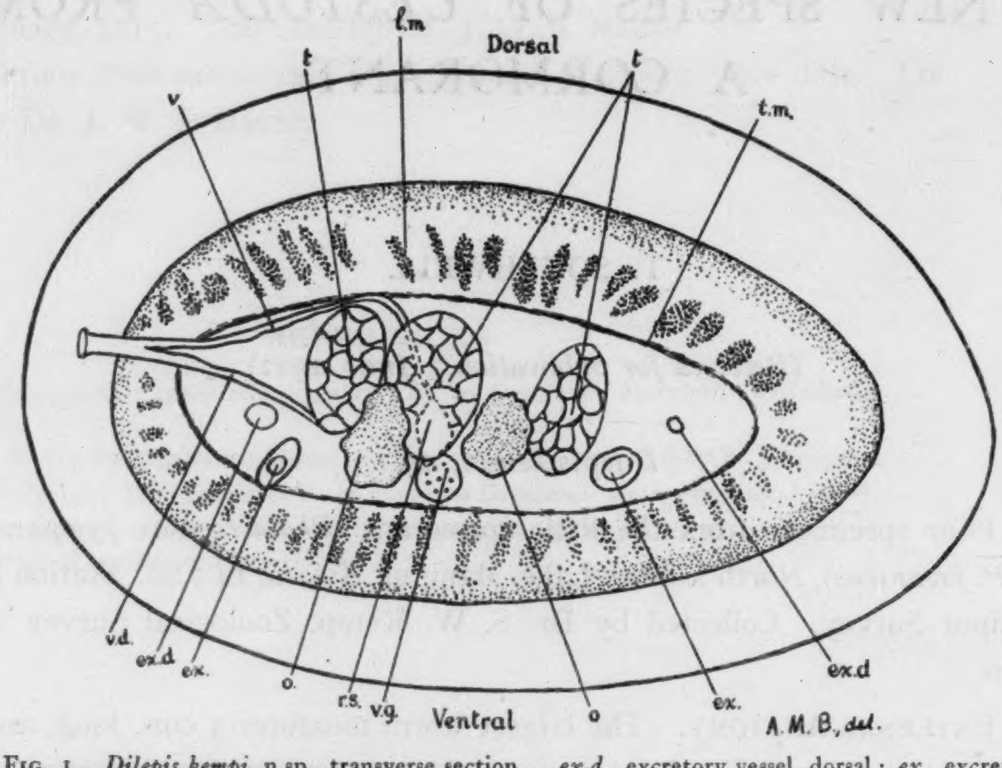

FIG. 1. *Dilepis kempi*, n.sp., transverse section. *ex.d.*, excretory vessel, dorsal; *ex.*, excretory vessel, ventral; *l.m.*, longitudinal muscles; *o.*, ovary; *r.s.*, receptaculum seminis; *t.*, testes; *t.m.*, transverse muscles; *v.*, vagina; *v.d.*, vas deferens; *v.g.*, vitelline glands. × 100.

The *vagina* is conspicuous, running dorsal to the *vas deferens* and water vessel. It opens in front of the *vas deferens*. It dilates a little into a seminal receptacle (figs. 1 and 2), close to the ovary.

The vitelline gland measures about 70μ by 50μ and lies posteriorly between the two wings of the ovary (figs. 1 and 2).

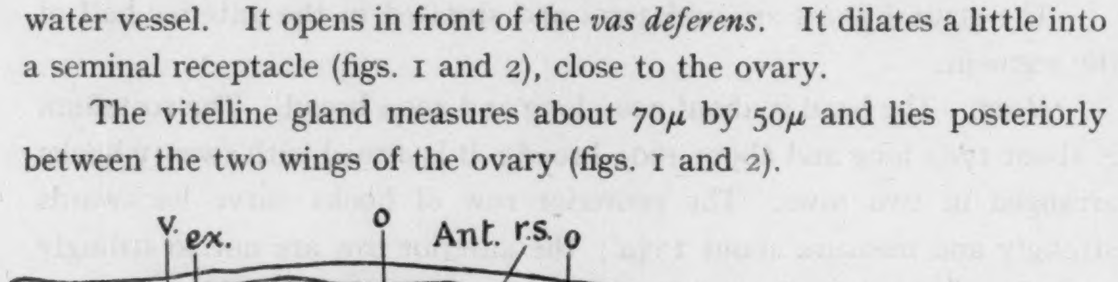

FIG. 2. *Dilepis kempi*, n.sp., horizontal section. *Ant.*, anterior; *e.x.*, excretory vessel; *o.*, ovary; *pst.*, posterior; *r.s.*, receptaculum seminis; *t.*, testes; *v.*, vagina; *v.g.*, vitelline gland. × 140.

Uterus. This is a large sac-like organ with very large and numerous outpocketings, extending lateral to the water vessels on both sides. No ripe eggs were seen.

Diagnosis. This species is distinguished from all other species of *Dilepis* on account of the large size of the rostellar hooks and the occurrence of three testes only. The presence of a double row of hooks shows that the species does not belong to the genus *Hymenolepis.*

We have named this species in honour of Dr. S. W. Kemp, Superintendent of the Zoological Survey of India, who collected the specimens.

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A CASE OF SUSPECTED LEPROSY

BY

J. W. W. STEPHENS

AND

S. ADLER

(*Received for publication 22 June, 1921*)

PLATE XVI

X.Y., age 16. Born in England, 1904. Has resided in Capetown, S. Africa, from 1905 until September, 1920.

History of Illness :—

April, 1920. Wasting noticed on dorsal side of left hand between 1st and 2nd metacarpals, and a stinging sensation in the little finger.

June, 1920. Three spots noticed on left side of face and brownish patches on both eyebrows. Later brownish patches noticed on left forearm and hand, and on both lower limbs.

August, 1920. Noticed deformity and impairment of movement in left hand.

Examination of the patient :—

1. A number of dry, scaly, brownish, thickened areas in part circumscribed up to three-eights of an inch in diameter, in part somewhat diffuse. None of these areas was anaesthetic except for those involved in the areas of anaesthesia, to be described later. The distribution of these is shown approximately in figs. 1 and 2.

2. A condition of claw hand (left). The actual condition can be appreciated from the photographs (Plate XVI).

3. Thickening of the left ulnar nerve which in the ulnar groove was about three times as thick as on the right side. The left internal cutaneous nerve was palpable and about a quarter of an inch thick.

4. The left forearm and hand were anaesthetic over an area shown approximately in figs. 1 and 2.

5. The left hand was colder to the touch than the right.

Diagnosis.—This species is distinguished from all other species of [illegible] by the large size of the posterior hooks and the [illegible] of three [illegible] only. The presence of a double row of hooks shows that the species does not belong to the genus [illegible].

We have received the [illegible] of Dr. S. W. Kemp, Superintendent of the Zoological Survey of India, who [illegible] the specimens.

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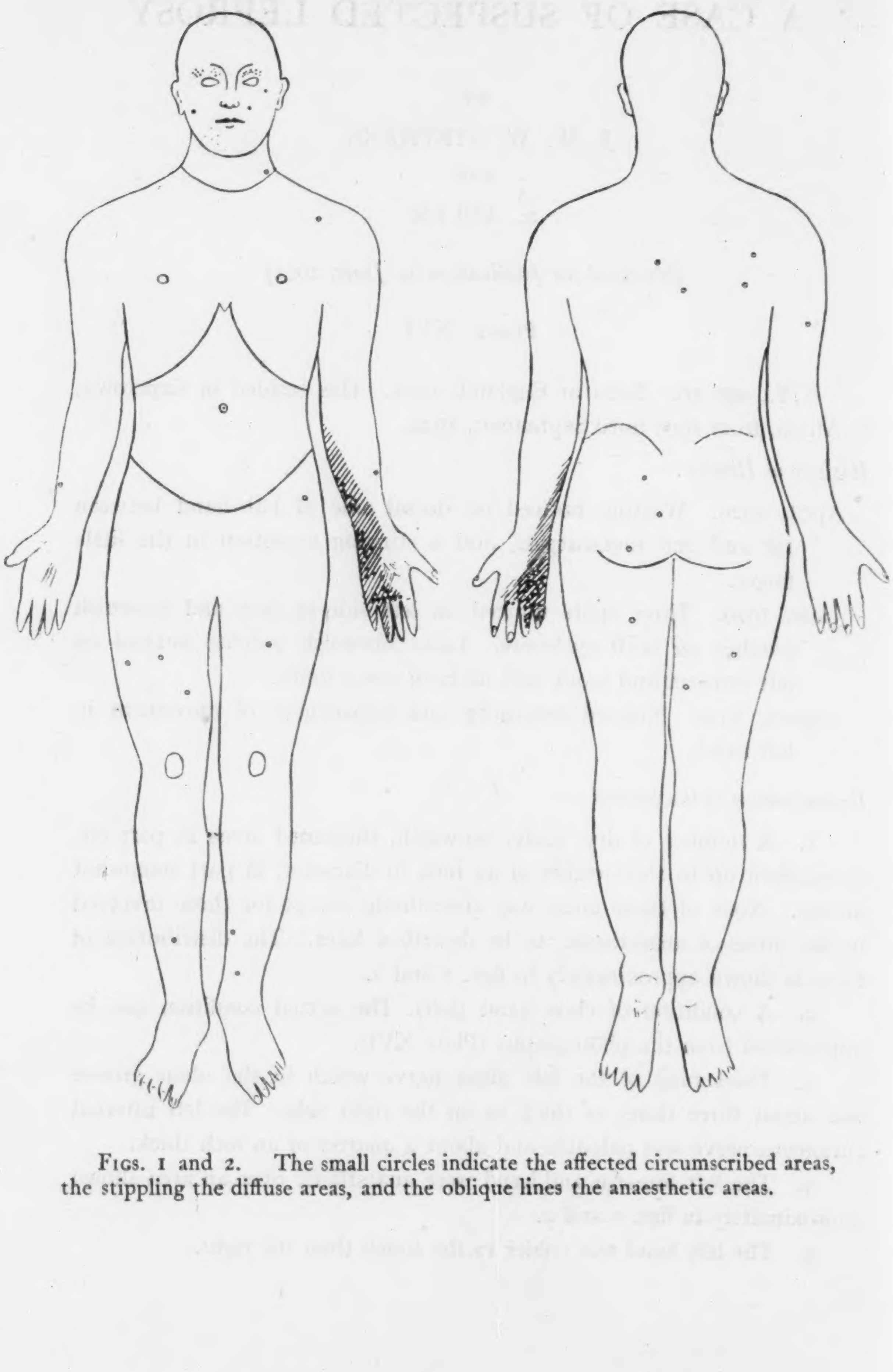

FIGS. 1 and 2. The small circles indicate the affected circumscribed areas, the stippling the diffuse areas, and the oblique lines the anaesthetic areas.

From 30.12.20 to 14.4.21 during his stay in the ward there was no rise of temperature.

27.1.21. The Wasserman reaction was completely negative.

On 7.2.21 and 21.2.21 the patient burned his left hand on the hot water-pipes of the ward without being aware of it.

Examination for Leprosy Bacilli :—

1. One of the affected areas on the left forearm was excised at the London School of Tropical Medicine, November, 1920, and examined by Dr. Low for leprosy bacilli with negative result.

2. Numerous scrapings and punctures of the various skin lesions, e.g., on the eyebrows, face, and of the nasal mucosa, were negative.

3. 2 c.c. of blood from a vein were haemolysed and centrifuged; the deposit was examined for leprosy bacilli with negative result.

4. A piece of the internal cutaneous nerve was excised, and sections and smears were stained for leprosy bacilli with negative result.

The excised nerve was examined for us histologically by Professor E. Glynn, who reported that 'there are three caseous areas apparently corresponding to large nerve bundles, surrounded by fibrous tissue in process of formation. No nerve fibres were seen. The appearance is quite consistent with fibro-caseous leprosy.'

On re-examination of the patient on 14.6.21 the only change noticed was a disappearance of affected areas on the dorsum of the hand and a diminution in extent of some of the areas on the face.

In view of the fact that no evidence of the presence of leprosy bacilli was obtained no treatment was adopted.

EXPLANATION OF PLATE XVI

Fig. 1. Ventral aspect of right and left hands. The left hand shows (*a*) its smaller size; (*b*) ill-defined cutaneous furrows; (*c*) wasting of the thenar and hypothenar eminences—flatness of the hand; (*d*) flexion of the interphalangeal joints of the 2nd, 3rd, 4th, and 5th fingers; (*e*) indication of the thickened rough skin areas at the base of 3rd, 4th, and 5th fingers; (*f*) the scar of a burn at the base of the hand on the ulnar side.

Fig. 2. Lateral view of the right and left hands. The left hands shows (*a*) wasting in the interspace between the 1st and 2nd metacarpal bones; (*b*) extension of the metacarpo-phalangeal joints and flexion at the interphalangeal joints; (*c*) wasting of the forearm.

PLATE XVI

Fig. 1

Fig. 2

Photographs by Miss M. Brown

C. Tinling & Co., Ltd., Imp.

OBSERVATIONS ON THE CERATOPOGONINE MIDGES OF THE GOLD COAST WITH DESCRIPTIONS OF NEW SPECIES

PART IV

BY

HENRY F. CARTER

A. INGRAM

AND

J. W. S. MACFIE

(*Received for publication 7 April, 1921*)

Genus *DASYHELEA*, Kieff.

Ceratopogon, Wtz. (*pro parte*) (*nec*. Mg. Edws.). *Linnea Entomologicae*. Vol. VI, 1852.
Culicoides, Kieff. et auct. (*pro parte*) (*nec*. Latr.).
Dasyhelea, Kieff. *Bull. Soc. Hist. Nat. Med.* Vol. III, 1911.
Prokempia, Kieff. *Rec. Ind. Mus.* Vol. IX, 1913.
Pseudoculicoides, Mall. *Bull. Ill. Sta. Lab. Nat. Hist.* Vol. X, 1915.
Dasyhelia, Brunetti. *Rec. Ind. Mus.* Vol. XVII, 1920.

This genus is closely related to *Culicoides*, Latr. It was erected by Kieffer in 1911 for the Indian species *D. halophila*, and subsequently (1913) divided by him into three sub-genera—*Dasyhelea* (sens. stric.), *Prokempia* and *Kempia*—according to the nature of the wing hairs and the empodium. Later (1917) the last two sub-genera were given generic rank by this author, who then associated *Prokempia* with *Dasyhelea* but removed *Kempia* to the *Atrichopogon* group. Still later (1919) Kieffer again placed *Prokempia* as a sub-genus of *Dasyhelea*. *Prokempia* apparently differs from *Dasyhelea* only in the absence or relative scarcity of the longer wing-hairs, and was separated for this reason; but although the density of arrangement of these hairs is much more uniform in *Dasyhelea* than in *Culicoides*, this character cannot, in our opinion, be considered of more than specific value.

Malloch, in 1915, founded the genus *Pseudoculicoides* for *Ceratopogon mutabilis*, Coq., especially distinguishing it from *Culicoides* by the absence of thoracic cavities and the antennal structure of the male. The description and figures of this species given by Malloch indicate that it is a typical *Dasyhelea*, and Kieffer (1919) accordingly placed *Pseudoculicoides* as a synonym of the latter. Malloch, however, made no reference to the eyes—the hairiness of which was given by Kieffer as one of the diagnostic characters of the genus—either in his generic definition or specific description; but Mr. F. W. Edwards, in a private communication, informs us that the eyes of specimens (named by Malloch) of *C. mutabilis* in the British Museum collection are shortly but distinctly hairy, and therefore Kieffer's decision in regard to this question must be accepted.

External Morphology.

The detailed anatomy of *Dasyhelea* differs from that of *Culicoides* (see Part II of this study, 1920) as follows:—

ADULTS. *Head.* Eyes in both sexes densely clothed with microscopic hairs.

Mouth-parts (fig. 1). Proboscis somewhat shorter than that

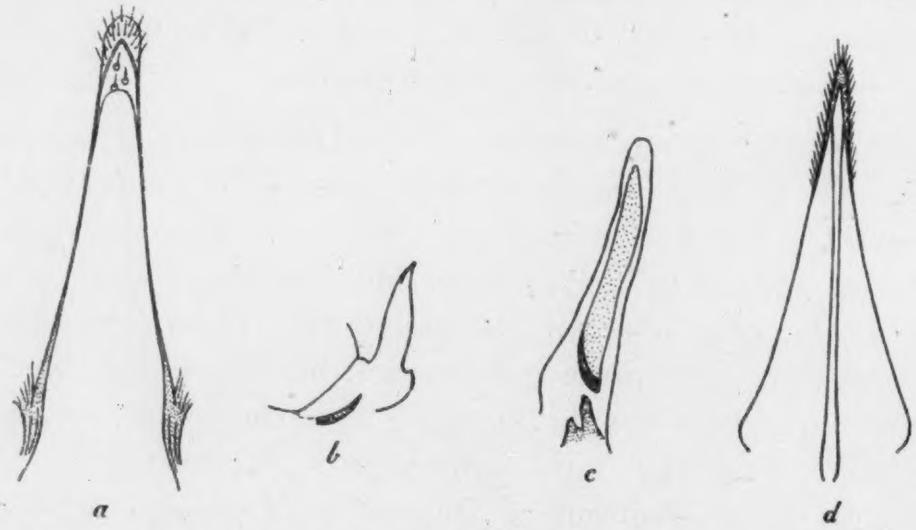

FIG. 1. Mouth parts of *D. pallidibalter* (♀): *a*—labrum; *b*—maxilla; *c*—mandible; *d*—hypopharynx. (× 490 circa.)

of *Culicoides*, the component organs, except the labium, differently formed and apparently not adapted for piercing in either sex. The labrum is strongly chitinised, broad at the base gradually tapering

to a rounded, hairy apex. The hypopharynx is similar in shape to the labrum, but tapers more rapidly and ends in a pointed apex; the distal fourth bears numerous hair-like marginal processes. The mandibles and maxillae are poorly developed and devoid of teeth; the former are closely applied to (and not easily separated from) the labrum and hypopharynx, and are enclosed in membranous sheaths which extend considerably beyond their extremities; the maxillae are rudimentary and are reduced to small, thinly chitinised, blade-like structures. The palpi in both sexes appear to be composed of four segments owing to the first being very rudimentary and often almost indistinguishable; the third segment is usually distinctly longer than the fourth or fifth and is scarcely swollen, with the minute sensory hairs scattered over the inner surface from the base almost to the apex—not concentrated in a relatively deep and sharply defined depression.

The above description of the mouth-parts is based upon dissections of two of the new species (*D. pallidihalter* and *D. flava*) described herein, and of the European *D. obscura*, Wtz. The structure of the various organs is apparently the same in males and females, and, in our opinion, is such that these midges would be incapable of piercing the skin. Malloch (1915), however, states that *D.* (*Pseudoculicoides*) *griseus*, Coq., 'was taken biting, on the bank of Sangamon River,' and that *D. cinctus*, Coq., has been 'recorded as biting human beings.' In Accra, specimens of *Dasyhelea* spp. occasionally alighted on the arm, but, so far as observed, they made no attempt to bite; possibly, therefore, the statement regarding *D. griseus* may have been due to a similar occurrence, and may subsequently require modification. At least, until the feeding habits of the midges of this genus have been carefully studied, the above statement must be regarded with reserve.

Antennae: segments of the flagellum in the female shorter and broader than in *Culicoides*, gradually lengthening towards the apex, but with the apical ones not distinctly differentiated from the basal; last four segments (twelve to fifteen) in the male, elongate, the twelfth to fourteenth inclusive cylindrical, binodose,* the whorls of

---

* The apical node is usually less well-developed than the basal node, and the hairs are shorter and more slender; but there is distinct variation in this respect, and in *D. flava*, sp. n. (see p. 196), the apical whorl is obsolete.

hairs arising from nodal rings situated on the basal and apical thirds of each segment. In both sexes, but more conspicuously in the males, the segments of the flagellum exhibit a tesselated or sculptured appearance, due to the presence of small chitinous plates, from the upper portion of each of which a hair arises; on the basal segments (four to eleven) in both sexes this sculpturing appears to be limited to the proximal portions (*i.e.*, the area below the whorls) of each, where the plates are sharply defined and radially arranged; on the distal segments the plates are arranged as shown in fig. 2.

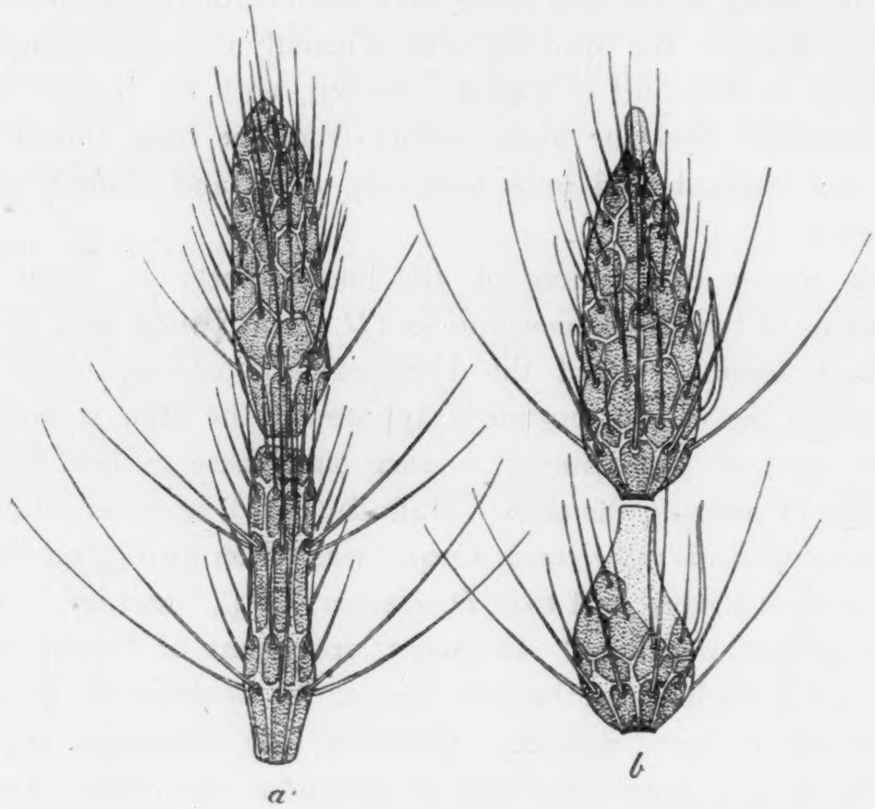

FIG. 2. Terminal segments of antennae of *a—D. fusciformis* (♂) and *b—D. inconspicuosa* (♀). (× 475 circa.)

Thorax without anterior or posterior pits or depressions; scutellum with a varying number of strong marginal or sub-marginal bristles and usually a few (one to six) short hairs.

Wings hyaline, unspotted; the venation very similar to that of *Culicoides*, but with the first and third veins less distinctly separated, so that normally only one interspace can be distinguished; in some species these veins appear to be completely fused.

Legs. Tibiae without apical spurs, but the fore and hind pairs with oblique or transverse rows of bristles distally; first tarsal

segments of all legs sub-equal, those of the middle legs not appreciably elongated. Claws small, equal, simple in the female, divided at the tips in the male; in both sexes the inner margin may be somewhat prominent, tooth-like, at the base, and agulate near the middle.

Abdomen. Dorsum covered with minute flattened spines; segments one to seven each with two small, clear, thinly chitinised, rounded areas. Spermatheca (fig. 9, *b-f*) single, heavily or moderately chitinised, usually sub-spherical, the commencement of the duct sometimes chitinised for a considerable distance.

*External genitalia of the male.** *Ninth segment*: tergite, apical lobe-like processes well developed, often projecting posteriorly beyond the tergite and sometimes bearing a median dorsal triangular chitinised plate; sternite not excavated, sometimes produced posteriorly in the middle line (c.f. figs. 10, 11). *Forceps*: side-pieces similar to those of *Culicoides*; claspers simple or divided, if the latter the branches variously formed, dissimilar. *Harpes* with the proximal portions greatly developed, highly chitinised, and in some species connected medially to form an uninterrupted, or almost uninterrupted, transverse bar. The distal portions show varying degrees of development and chitinisation, and in all the species, except one, examined by us, the distal portion—bent sharply and directed posteriorly—of only one harpe is developed, thus causing asymmetry; in the exception referred to (*D. similis*, sp. n.) the distal portions of both harpes appear to be developed, but are fused in the middle line forming a conspicuous median structure. *Aedoeagus* strongly chitinised, usually broad but of variable form.

* In regard to the nomenclature of the hypopygial structures adopted in this and previous studies, Parts II and III (1920-1921), on the Ceratopogonine midges of the Gold Coast, Mr. F. W. Edwards writes us as follows :—' I now think that your harpes are the same structures which de Meijere has called gonapophyses in the Limnobiidae, and I was probably right in homologising them with the parameres of Culicidae. There is one difference, at first sight fundamental, in that in *Culicoides* and Limnobiidae (e.g., *Eriocera*) the structures are dorsal to the aedoeagus, adjoining the tenth sternite (which I consider to be represented by your spicular strip of membrane), whereas in the mosquitoes they are morphologically ventral to the aedoeagus. However, it would seem likely that this is connected with the atrophy of the anal chitinisations in *Culicoides* and the Limnobiidae, the parameres moving dorsally and fusing in the mid-dorsal line in order to replace, in function, the tenth sternite. In other insects the parameres are said to be normally lateral in position, so that it is easy to understand that they might pass either dorsally or ventrally. In any case the important idea to lay hold of is that the parameres form with the basal plate the first (morphologically innermost) ring of the genital tube, the second ring being the mesosome which is more or less invaginated into the first. In *Culicoides* I believe the structure you call the aedoeagus is really the basal plate only, and that there is no mesosome. Properly speaking the term aedoeagus should include in this case also the " harpes." The two small chitinous appendages of the ninth tergite, of course, represent the tenth tergite.'

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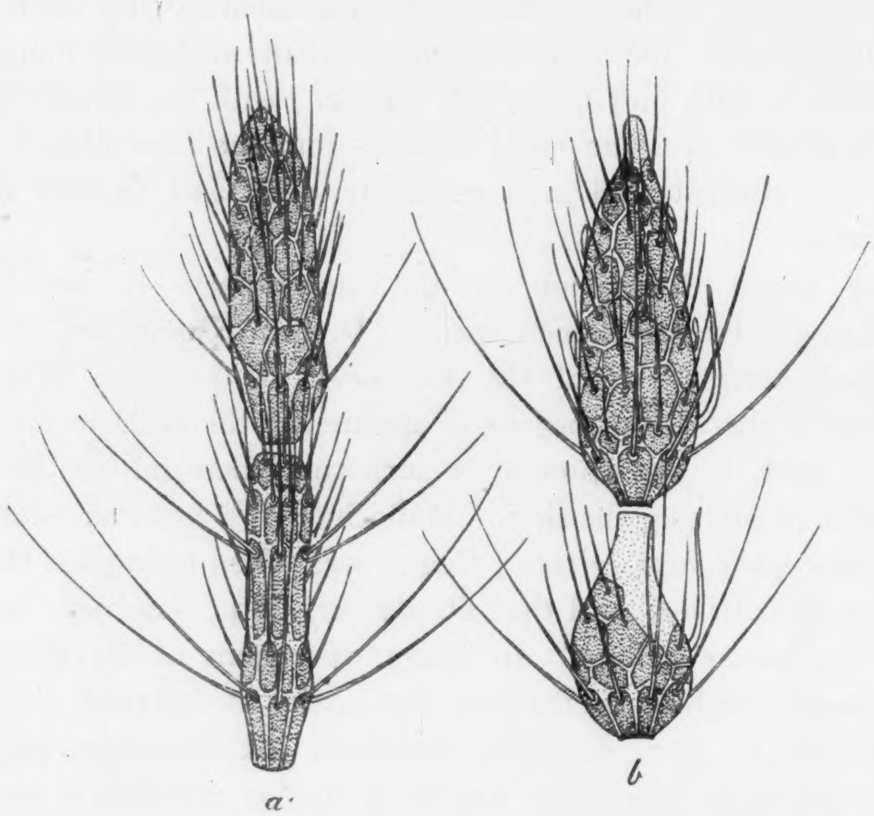

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Legs. Tibiae without apical spurs, but the fore and hind pairs with oblique or transverse rows of bristles distally; first tarsal

segments of all legs sub-equal, those of the middle legs not appreciably elongated. Claws small, equal, simple in the female, divided at the tips in the male; in both sexes the inner margin may be somewhat prominent, tooth-like, at the base, and agulate near the middle.

Abdomen. Dorsum covered with minute flattened spines; segments one to seven each with two small, clear, thinly chitinised, rounded areas. Spermatheca (fig. 9, *b-f*) single, heavily or moderately chitinised, usually sub-spherical, the commencement of the duct sometimes chitinised for a considerable distance.

*External genitalia of the male.** *Ninth segment*: tergite, apical lobe-like processes well developed, often projecting posteriorly beyond the tergite and sometimes bearing a median dorsal triangular chitinised plate; sternite not excavated, sometimes produced posteriorly in the middle line (c.f. figs. 10, 11). *Forceps*: side-pieces similar to those of *Culicoides*; claspers simple or divided, if the latter the branches variously formed, dissimilar. *Harpes* with the proximal portions greatly developed, highly chitinised, and in some species connected medially to form an uninterrupted, or almost uninterrupted, transverse bar. The distal portions show varying degrees of development and chitinisation, and in all the species, except one, examined by us, the distal portion—bent sharply and directed posteriorly—of only one harpe is developed, thus causing asymmetry; in the exception referred to (*D. similis*, sp. n.) the distal portions of both harpes appear to be developed, but are fused in the middle line forming a conspicuous median structure. *Aedoeagus* strongly chitinised, usually broad but of variable form.

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* In regard to the nomenclature of the hypopygial structures adopted in this and previous studies, Parts II and III (1920-1921), on the Ceratopogonine midges of the Gold Coast, Mr. F. W. Edwards writes us as follows :—' I now think that your harpes are the same structures which de Meijere has called gonapophyses in the Limnobiidae, and I was probably right in homologising them with the parameres of Culicidae. There is one difference, at first sight fundamental, in that in *Culicoides* and Limnobiidae (e.g., *Eriocera*) the structures are dorsal to the aedoeagus, adjoining the tenth sternite (which I consider to be represented by your spicular strip of membrane), whereas in the mosquitoes they are morphologically ventral to the aedoeagus. However, it would seem likely that this is connected with the atrophy of the anal chitinisations in *Culicoides* and the Limnobiidae, the parameres moving dorsally and fusing in the mid-dorsal line in order to replace, in function, the tenth sternite. In other insects the parameres are said to be normally lateral in position, so that it is easy to understand that they might pass either dorsally or ventrally. In any case the important idea to lay hold of is that the parameres form with the basal plate the first (morphologically innermost) ring of the genital tube, the second ring being the mesosome which is more or less invaginated into the first. In *Culicoides* I believe the structure you call the aedoeagus is really the basal plate only, and that there is no mesosome. Properly speaking the term aedoeagus should include in this case also the "harpes." The two small chitinous appendages of the ninth tergite, of course, represent the tenth tergite.'

PUPA. The pupae of *Dasyhelea* much resemble those of *Culicoides*, the chief point of difference being in the reduction of the first and elongation of the second abdominal segments, the shape and structure of the respiratory trumpets and the arrangement of tubercles on the body.

The structure of the trumpets, as shown in the species examined by us, is of especial interest since forms occur which represent transitional stages between the simple type, as exemplified by *Culicoides*, and the complex type as found in at least some species of *Forcipomyia* (e.g., *F. ingrami*, Cart., 1919). Such forms are shown in fig. 3, *b-d*; the last type figured evidently represents

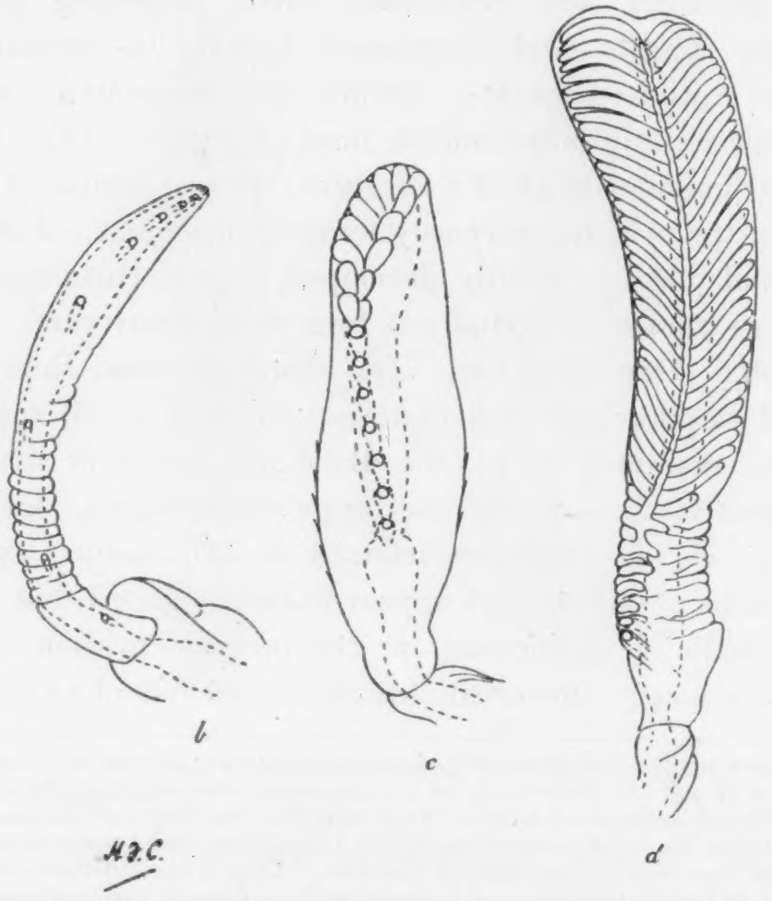

FIG. 3. Pupal trumpets of *b—D. flaviformis*; *c—D. ingrofusca*; *d—D. fusca*. (*b—c* × 360 circa; *d* × 220.)

a stage in development immediately preceding that occurring in *Forcipomyia*, for by a simple folding back of the distal leaf-like portion an organ very similar in structure to the trumpet of *F. ingrami* could be produced.

The chief differences in the arrangement of the body tubercles is as follows:—*Cephalothorax*: anterior dorsal tubercles absent, anterior dorso-median tubercles present (as in *Stilobezzia*), dorsal, postero-dorsal, and ventro-median tubercles absent but sometimes represented by minute hairs; the dorsal surface of the thoracic portion is thus entirely devoid of distinct tubercles, but is, on the other hand, usually pigmented or striated in circumscribed areas. *Abdomen*: tubercles flattened and flange-like, the dorsal antero-submarginal tubercles small or rudimentary, one only on each side; the postero-marginal tubercles are situated, as in *Stilobezzia*, near the middle transverse line of each segment, around which they form an almost continuous (interrupted in the middle line of the dorsal and ventral surfaces) band; on segments three to seven they are nine in number, of which the three central ones (ventro-lateral tubercles) are the most highly developed. In some species small, rounded, pigmented areas, arranged in the form of a triangle, are present on both dorsal and ventral surfaces.

The terminal processes are broad and flattened, and are directed dorsally and laterally; at the base of each are two prominent tubercles bearing hairs and spines.

LARVA. The mature larva differs from that of *Culicoides* chiefly in regard to the size and shape of the head, the position of the eyes and in the possession of a small hooked pseudopod at the posterior extremity of the body (fig. 9, *g*).

The *head* is distinctly larger (almost twice as large as in *Culicoides*) and tapers more strongly towards the apex, being obovate rather than sub-conical; it bears minute hairs only. The eyes are reniform and are situated far forwards, near the anterior third. The mouth-parts are similar in structure to those of *Culicoides*, but, in the three West African species observed, appear to be rather more highly developed in so far as the hypopharynx is larger and more complex, the mandibles are tridentate and the labium is more highly chitinised and more strongly serrated. The *body* is elongate and scantily clothed with very minute hairs; the anal pseudopod is retractile, small and membranous, and bears two dorsal and two ventral groups of small but strongly chitinised, recurved hooks which are directed anteriorly. The anal papillae are short, bifid, with slightly blunted extremities.

Specific Descriptions.

Dasyhelea pallidihalter, sp. n.

Measurements.	Female.	Male.
Length of body*	1·3 mm.	1·3 mm.
Length of wing	0·8 mm.	0·8 mm.
Greatest breadth of wing	0·3 mm.	0·3 mm.

Head dark brown, clothed with dark hairs. Eyes narrowly separate in both sexes. Proboscis and palpi brown, the latter with the third segment uniformly and slightly swollen and almost twice as long as the fifth; the second, fourth and fifth short, sub-equal. *Antennae* dark brown with dark brown hairs; in the female the segments of the flagellum are sub-spherical at the base, gradually lengthening, becoming oval, towards the apex, the fourth to eleventh each bearing a pair of large, strong, bluntly rounded spines; in the male, segments four to eleven are sub-spherical to ovoid in shape, the length from two-thirds to one and one-third times the greatest breadth, segments twelve to fifteen are elongate, about three times as long as wide, the last broader and pointed distally, the twelfth to fourteenth sub-cylindrical, each distinctly binodose. *Thorax* dark brown with small yellowish-brown areas in the humeral angles and over the roots of the wings. Scutellum dark brown, becoming brownish-yellow centrally, bearing four centro-marginal and two lateral bristles, and a median transverse row of about six short hairs. Post-scutellum and pleurae dark brown. *Wings* in the female well clothed with decumbent hairs which extend almost to the base between the fourth and fifth veins and are numerous in the anal angle and fork of the fifth vein. Costa and first and third longitudinal veins not extending to the middle of the anterior border, terminating above or slightly beyond the bifurcation of the fifth vein and enclosing a small but distinct cell or interspace; in the male less hairy (no hairs at the base of the wing, and very few, if any, in the anal angle or fork of the fifth vein), the costa terminating slightly before the bifurcation of the fifth vein. Halteres white, or almost white. *Legs* uniformly dark brown. Claws in both sexes with the inner margin at the base somewhat produced, and near the middle with a small, angulate prominence. *Abdomen*: dorsum

* In all cases taken from the anterior margin of the thorax to the tip of the abdomen of specimens mounted in carbolic.

dark brown, sparsely clothed with dark brown hairs, venter rather paler brown. Spermatheca highly chitinised, spherical (diameter 50μ) with a conical posterior extension (length about 20μ) leading to the duct.

HYPOPYGIUM (fig. 4). *Ninth segment*: tergite short and broad, relatively strongly chitinised and sparsely clothed with moderately long, strong hairs, posterior margin straight, produced on each side into a small, rounded, hairy knob, apical lobe-like processes well developed, often extending as a centrally indented membrane considerably beyond the extremity of the tergite; sternite broad,

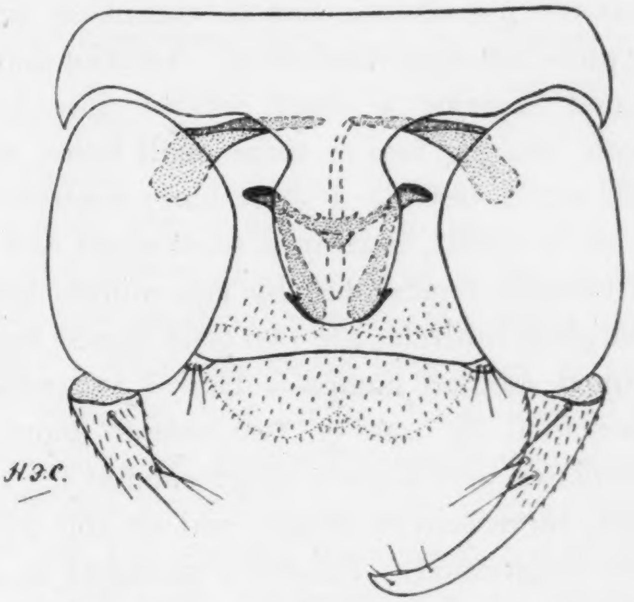

FIG. 4. *D. pallidibalter*, sp.n., male hypopygium (ventral view). × 400 circa.

produced centrally and posteriorly into a relatively large, more or less oval, lobe-like process. *Forceps*: side-pieces well chitinised and with long hairs, as in *Culicoides*; claspers long and slender, rather strongly chitinised, the basal half pubescent with a few strong hairs, the apex pointed, slightly depressed, bearing two or three short, delicate hairs. *Harpes* as shown in fig. 4, the proximal portions very strongly chitinised, the distal portion—only that of the left* harpe is developed—very feebly chitinised, narrow and bent almost at a right angle to the proximal portion. *Aedoeagus* somewhat V-shaped, relatively short, the lateral arms with outwardly directed,

* In this and all subsequent species in which the harpes are not symmetrically developed, the side of the insect from which the distal portion arises is stated. The figures of the hypopygium, however, show the ventral aspect and therefore in them the right side of the insect lies to the left of the reader.

pointed, beak-like, distal processes and connected anteriorly by a slightly curved, centrally thickened chitinous bar.

PUPA. Length 1·9 mm. Integument pale brownish-yellow, not infuscated in any part or heavily shagreened except on the operculum and on the posterior abdominal segments. *Respiratory trumpets* narrow and strongly curved, almost semi-circular; length about 0·3 mm. The trumpets are obliquely and irregularly ringed, the tracheal trunk in each gives off a number of short lateral branches, which lead to small elevations on the surface, and terminates distally in five or six short, blunt processes. *Cephalothorax*: dorsum of thoracic portion not pigmented, smooth except on anterior border, and with a few puckered or striated areas. Anterior marginal tubercle large, shagreened, bearing a short bristle; dorso-lateral tubercle rounded, smooth, bearing two or three small hairs, anterior dorso-median tubercle small, bearing a short hair; ventro-lateral tubercle moderately large, rounded, bearing a short spine and a short hair; ventro-median tubercle represented by two minute hairs. Between the anterior marginal tubercles are two (one dorsal and one ventral) rounded, unarmed median humps. Dorsal tubercles absent, but anteriorly represented by one or two minute hairs. *Abdomen*: integument reticulated and slightly shagreened at the sides and base of each segment, more heavily shagreened on the distal segments, the last entirely shagreened. Tubercles arranged as mentioned on page 183, the antero-submarginal tubercle small armed with a short spine, the dorsal and ventral postero-marginal tubercles apparently unarmed, low, broad and flange-like, the ventro-lateral postero-marginal tubercles larger and conical, the middle bearing a short hair, the others a short spine. Terminal processes broad and flattened, directed dorsally and laterally, each with two posterior tubercles, bearing respectively a hair and a spine.

LARVA. Length about 3 mm. *Head* obovate, convex dorsally, flattened ventrally; length 0·2 mm., greatest breadth 0·12 mm. Hairs scanty, minute. Mental plate crescentic, moderately chitinised, apparently bearing nine teeth on each side, the last large and broadly rounded, the others small, narrowly rounded and closely apposed. Mandibles large, highly chitinised, the distal portion bearing three large teeth on the inner side. Hypopharyngeal sclerite very highly chitinised posteriorly, the posterior portion

armed with three rows of teeth and with a delicate, serrated, fringe-like expansion on each side. *Body* scantily clothed with minute hairs, the last segment with apparently eight pairs of very small hairs near the extremity. Posterior pseudopod (fig. 9, *g*) small, the dorsal groups each consisting of two hooks, the ventral groups each of four hooks.

HABITAT: Nsawam, Gold Coast. Reared from rotting material collected from the base of a banana plant; March to May, 1920.

Dasyhelea fusciscutellata, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body (two specimens)	1·0 mm.	1·1 mm.
Length of wing	0·8 mm.	0·8 mm.
Greatest breadth of wing	0·3 mm.	0·3 mm.

Head dark brown with almost black hairs. Eyes narrowly separate in the female, very narrowly separate in the male. Clypeus, proboscis and palpi brown; third segment of the latter cylindrical, slightly and uniformly swollen, about as long as the fourth and fifth segments together. *Antennae* brown with black hairs and, except on the last five segments, long spines; in the female the segments ovoid and sub-equal in size gradually elongating towards the apex, but the thirteenth and fourteenth segments slightly longer than the eleventh and twelfth, last segment the longest, not produced distally into a stylet; in the male, segments four to eleven spheroidal, gradually becoming narrower and more elongate apically, the last four segments longer, the twelfth and thirteenth sub-equal in length, each slightly longer than the fourteenth, the last segment about as long as the penultimate and without a terminal stylet, segments twelve to fourteen distinctly binodose. *Thorax* dark brown with black hairs, the anterior lateral angles sometimes of a pale brown colour. Scutellum dark brown with four centro-marginal bristles, two lateral bristles, and two small hairs. Postscutellum and pleurae dark brown. *Wings* sparsely clothed with decumbent hairs which extend basally between the fourth and fifth veins beyond the anterior cross vein. In the female the costa terminates near the middle of the anterior border but extends well beyond the bifurcation of the fifth vein, and the first and third veins form distally a somewhat indefinite cell; in the male, the costa ends before the bifurcation of

the fifth vein and the first and third longitudinal veins form a distinct cell. Halteres with tawny-yellow knobs and dark brown stems. *Legs* brown, uniformly coloured; claws with a basal hairy extension, of the female simple, each with a slight sub-central projection, of the male bifid distally, each with a distinct sub-central projection. *Abdomen* dark brown with black hairs. Spermatheca (fig. 9, *f*) heavily chitinised, somewhat reniform, the anterior portion ovoid (length 46μ, breadth 49μ), the posterior portion (length 18μ) narrower and sharply curved.

HYPOPYGIUM (fig. 5). *Ninth segment*: tergite broad, slightly tapering posteriorly and bearing a few moderately long hairs dorsally, posterior margin without a central notch and with the lateral finger-like processes small, apical lobe-like processes well

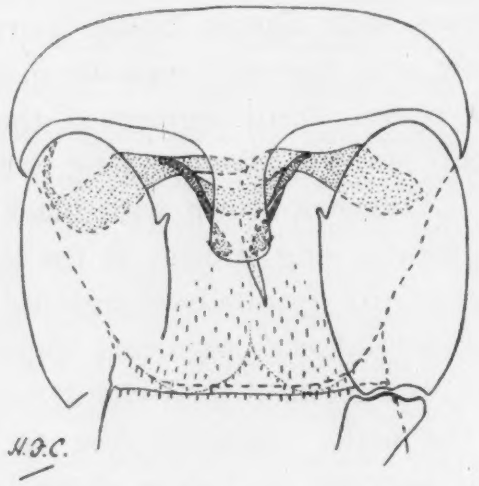

FIG. 5. *D. fusciscutellata*, sp.n., male hypopygium (ventral view). × 400 circa.

developed and with a median triangular dorsal chitinised plate between them; sternite with a somewhat rectangular median posterior projection. *Forceps*: side-pieces strongly chitinised, with long hairs; claspers well chitinised, the basal halves pubescent and bearing one or two relatively stout hairs, the distal extremities slightly depressed. *Harpes*: basal portions strongly chitinised, broad laterally, narrowing towards the middle line; from the left basal portion a feebly chitinised, slightly curved, pointed, blade-like process projects posteriorly as far as the middle of the side-pieces. *Aedoeagus*: median transverse basal portion not very broad, heavily chitinised and slightly twisted and bevelled laterally, lateral portion

strongly chitinised, the distal extremities hook-like and directed dorsally.

HABITAT: Nsawam, Gold Coast. Reared from materials collected from the bases of banana plants, March, 1920.

Dasyhelea similis, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·1 mm.	1·0 mm.
Length of wing	0·7 mm.	0·7 mm.
Greatest breadth of wing	0·3 mm.	0·2 mm.

Head dark brown with dark brown hairs. Eyes narrowly separate in both sexes. Clypeus, proboscis and palpi brown, the third palpal segment slightly but distinctly swollen at the base and attenuated distally, in the female about as long as the fourth and fifth segments together, in the male relatively shorter, about as long as the fifth. *Antennae* brown with brownish-black hairs and, except on the last five segments, long, clear spines; in the female the segments, with the exception of the last, which is the longest but carries no stylet, are all sub-equal in size and ovoid in shape, any one of the apical segments (twelve to fourteen) being, if anything, slightly shorter than any one of the five (seven to eleven) preceding; in the male, segments four to eleven spheroidal gradually becoming narrower and longer towards the apex, the last four segments elongate, twelfth and thirteenth sub-equal, longer than the others, twelfth to fourteenth distinctly binodose. *Thorax* dark brown, the anterior lateral angles sometimes paler brown. Scutellum dark brown with four* centro-marginal and two lateral bristles, and two or more small hairs. Post-scutellum and pleurae dark brown. *Wings* sparsely clothed with decumbent hairs which scarcely extend basally beyond the cross-vein; in the male the costa extends slightly beyond the middle of the wing, its end lying above the fork of the fifth vein, and the first and third veins form a distinct cell; in the female the costa extends beyond the middle of the wing and terminates distally to the fork of the fifth vein, forming with the first and third vein a somewhat indefinite cell. Halteres with pale yellow knobs and dark brown stems. *Legs* uniformly brown. Female claws simple, male claws bifid with a slight indication of a sub-central projection; in both sexes with a hairy extension

* The two middle centro-marginal bristles may be replaced by a single central bristle in this and other species of *Dasyhelea*.

at the base. *Abdomen* dark brown clothed with dark hairs. spermatheca (fig. 9, *e*) sub-spherical (diameter 46μ), moderately chitinised, the duct scarcely chitinised at its commencement.

HYPOPYGIUM (fig. 6). *Ninth segment*: tergite scarcely tapering posteriorly, the margin straight with rudimentary finger-like processes each bearing two setae, the apical lobe-like processes large; sternite not produced posteriorly. *Forceps*: side-pieces clothed with long hairs, claspers strongly chitinised, the basal halves pubescent, the apical halves bearing one or two short hairs near their distal extremities which are depressed. *Harpes*: basal portions curved, ribbon-like, symmetrical, joined medially, forming a

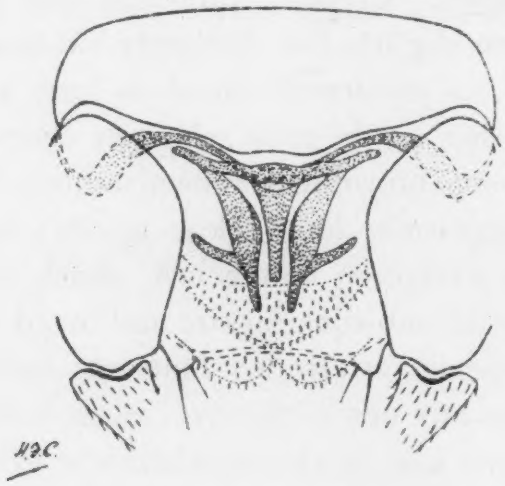

FIG. 6. *D. similis*, sp.n., male hypopygium (ventral view). × 400 circa.

transverse bar from the centre of which a heavily chitinised structure (representing the fused distal portions) extends posteriorly and ends in a rather blunt point. *Aedoeagus*: median transverse basal portion strongly chitinised, narrow, somewhat thickened in the middle (triangular in some views), and but slightly curved, lateral portion terminating in moderately sharp points and bearing dorsally a strongly developed barb which projects transversely and is curved in an anterior direction.

HABITAT: Nsawam, Gold Coast. Reared from rotting material collected from the bases of banana plants, March, 1920.

D. similis closely resembles *D. fusciscutellata* but is of a rather lighter colour, generally with lighter yellow halteres; the species may be readily distinguished by the form of the spermatheca in the females and the structure of the hypopygium in the males.

Dasyhelea luteoscutellata, sp. n.

MEASUREMENTS.	Female.
Length of body (one specimen)	1·1 mm.
Length of wing	0·8 mm.
Greatest breadth of wing	0·3 mm.

Head dark brown with dark hairs. Eyes narrowly separate. Clypeus, proboscis and palpi brown, the third palpal segment longest, slightly swollen basally, the fourth and fifth segments together longer than the third. *Antennae* brown with dark brown hairs and long spines, curved and somewhat hair-like, on segments four to ten, inclusive; the latter segments sub-spherical to ovoid, elongating towards the apex, the terminal five segments distinctly more elongate, together longer than segments three to ten united, the last segment without a stylet. *Thorax* dark brown with dark hairs. Scutellum bright yellow with four centro-marginal and two lateral bristles, and a small central hair. Post-scutellum and pleurae dark brown. *Wings* similar to those of *D. pallidihalter*. Halteres with white knobs and dark brown stems. *Legs* brown, uniformly coloured. Claws simple without a sub-central prominence. *Abdomen* dark brown clothed with dark brown hairs. Spermatheca sub-spherical (diameter 43μ); the duct chitinised for a short distance only.

HABITAT: Nsawam, Gold Coast. Reared from material collected from the base of a banana plant; the pupa and larva were not identified.

This species is a small, dark brown or almost black midge, resembling *D. pallidihalter* but with the scutellum entirely bright yellow, not darkened laterally; the long spines on the basal segments of the antennae are more slender and hair-like than in *D. pallidihalter*.

Dasyhelea inconspicuosa, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body (two specimens)	1·0 mm.	1·1 mm.
Length of wing	0·7 mm.	0·9 mm.
Greatest breadth of wing	0·4 mm.	0·5 mm.

Head dark brown. Eyes broadly contiguous in the female, narrowly separate in the male. Proboscis and palpi brown, the

latter relatively long, the third segment elongate, cylindrical, as long as the fourth and fifth segments together, the second segment about half the length of the third. *Antennae* brown with dark brown hairs; in the female, segments four and five sub-spherical, six to fifteen oval, gradually becoming longer towards the apex, the last segment broad without a stylet (fig. 2, *b*); in the male, segments four to eleven spheroidal to ovoid, segments twelve to fifteen elongate, the twelfth and thirteenth sub-equal, longer than the fourteenth and fifteenth, the last segment rather shorter than the fourteenth, without a stylet. *Thorax* dark brown with dark hairs. Scutellum yellowish brown with four centro-marginal and two lateral bristles in both sexes, small hairs absent. Post-scutellum and pleurae dark brown. *Wings* densely clothed with decumbent hairs, which in the female extend to the base between the fourth and fifth veins. In the female the costa extends to about the middle of the anterior margin, its extremity distal to the bifurcation of the fifth vein, forming with the first and third veins a narrow, slit-like cell; in the male the costa scarcely reaches the middle of the anterior margin and terminates above the bifurcation of the fifth vein. Halteres with pale brown knobs and dark brown stems. *Legs* brown. Male claws bifid at their extremities and with a minute sub-basal hairy extension on their inner sides; female claws simple, with a sub-basal extension similar to that of the male, but smaller. *Abdomen*: dorsum dark brown with brown hairs, venter paler brown. Spermatheca strongly chitinised, spherical (diameter 32μ), the chitinised portion of the duct straight (length 5μ).

HYPOPYGIUM (fig. 7). *Ninth segment*: tergite scarcely tapering towards its posterior extremity and scantily clothed with long, stout hairs, the finger-like processes moderately small and somewhat pointed, each bearing a relatively long hair near the apex and four near the base, apical lobe-like processes well developed and bearing between them a small triangular chitinised plate (not shown in the figure), sternite prolonged centrally and posteriorly into a long narrow process which covers the aedoeagus and ends in what looks like, but actually is not a strongly chitinised spine. *Forceps*: side-pieces well chitinised, with very long hairs, claspers with the basal halves pubescent and the tips depressed, and bearing a few minute hairs. *Harpes*: basal portions heavily chitinised, broad

laterally and somewhat L-shaped; distal portion of the left harpe developed but small, slender and feebly chitinised. *Aedoeagus*: median transverse proximal portion slightly curved and tapering laterally; lateral portions look as if they were twisted, apparently each composed of two plates, between them a tapering median gutter-like process with a blunt end (not shown in the figure); the junction between the plates on each side is very thinly chitinised.

PUPA: Length (two specimens) 2 mm.; dorsum of the cephalothorax somewhat infuscated anteriorly, the anterior margin and the

FIG. 7. *D. inconspicuosa*, sp.n., male hypopygium (ventral view), × 400 circa.

posterior end of the abdomen conspicuously shagreened. *Respiratory trumpets*: length about 0·2 mm.; curved, and conspicuously ringed except at the extremities. The main tracheal trunk gives off laterally, at fairly regular intervals, a few processes which open on elevations slightly larger than the ordinary corrugations of the trumpet, and apically about eight short blunt processes arranged in a fan-like manner. *Cephalothorax* without strongly armed tubercles. Anterior marginal tubercles divergent, dark coloured,

and covered with coarse dark spicules bearing a minute terminal hair; between the anterior marginal tubercles are two small dark elevations, one behind the other, covered with coarse dark spicules; anterior dorso-median tubercles triple, each with small setae internally; dorso-lateral tubercles each showing two slightly rounded elevations bearing small delicate hairs. Dorsal tubercles represented by a few minute hairs, and on each side of the middle line are three dark puckered macules, forming an irregular row across the dorsum; in front of this row on each side are three similar, if less distinct, macules. *Abdomen*: the arrangement of tubercles and form of the terminal processes are similar to those of the preceding species.

LARVA. Length 2·6 mm., greatest breadth 0·2 mm. (two specimens, apparently not quite mature). *Head*: length about 0·2 mm., greatest breadth 0·14 mm.; well chitinised, conical. Mental plate resembling that of *D. pallidihalter*, but apparently with five rather large coarse teeth on each side instead of eight.

HABITAT: Oblogo; reared from pupae found in collections of water in the bottoms of canoes tied to the bank of the river Densu, also from rotten wood taken from the sides and ends of the same canoes; December, 1919, to March, 1920. Also larvae, pupae and adults in the collection of the Liverpool School of Tropical Medicine obtained from the rotting vegetation at the sides of a water hole at Christiansborg, Accra, March, 1918.

Dasyhelea nigricans, sp. n.

MEASUREMENTS.	Male.
Length of body	1·3 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·3 mm.

Head very dark brown, almost black. Eyes narrowly separated. Clypeus and proboscis dark brown. Palpi brown with dark hairs, third segment the longest, but not so long as the fourth and fifth together and not appreciably swollen, the last segment distinctly longer than the fourth. *Antennae* very dark brown with a plume of black hairs. Segments four to eleven spheroidal, the last four segments more elongate, sub-equal in length, without long spines, the last slightly shorter than the penultimate and without a stylet; segments twelve to fourteen distinctly binodose.

Thorax dark brown, almost black, with small yellowish-brown patches at the anterior lateral angles and over the bases of the wings. Scutellum orange brown in the middle, dark brown at the sides, bearing four centro-marginal and two lateral bristles, and one or two median short hairs. Post-scutellum and pleurae dark brown. *Wings* sparsely clothed with decumbent hairs. The costa terminates about the middle of the wing and proximal to the bifurcation of the fifth vein; the first and third veins form distally a single small cell. Halteres with yellowish-brown knobs and dark brown stems. *Legs* brown, almost uniformly coloured, the femora and two terminal tarsal segments slightly darker. Claws bifid distally without a sub-basal projection. *Abdomen*: dorsum very dark brown, scantily clothed with black hairs, venter distinctly lighter in colour.

HYPOPYGIUM (fig. 8). *Ninth segment*: tergite long, reaching beyond the ends of the side-pieces, tapering posteriorly and showing

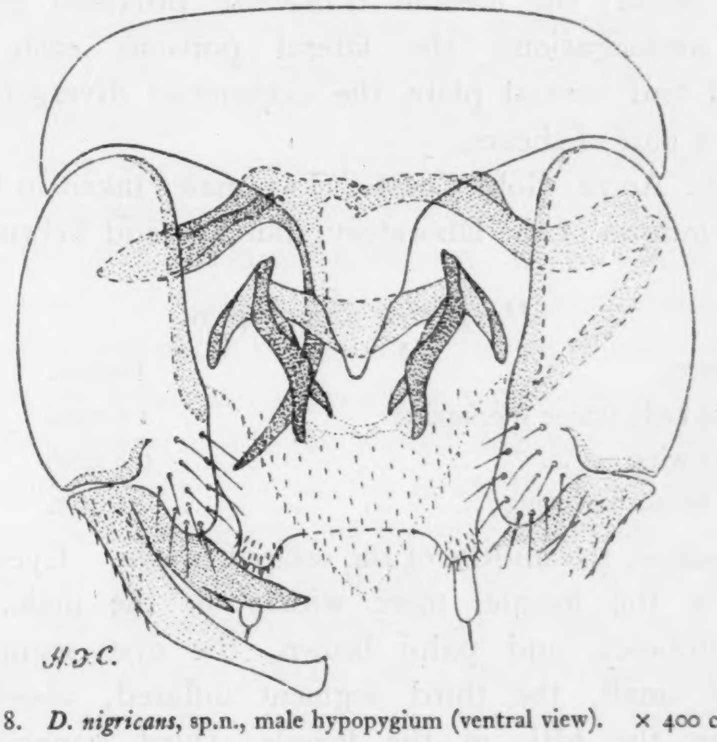

FIG. 8. *D. nigricans*, sp.n., male hypopygium (ventral view). × 400 circa.

a slight concavity at its posterior margin, clothed dorsally with a few moderately long hairs, finger-like processes well developed, dark, each with a rounded apex bearing a small terminal hair; sternite prolonged posteriorly into a cone-like process. *Forceps*: side-pieces prolonged distally on their inner sides into sub-conical, thinly chitinised lobes which are clothed with short, stout hairs—the

inner margin from the base of each side-piece as far as the origin of the lobes is very heavily chitinised; claspers double, the inner piece more heavily chitinised and shorter than the outer, pubescent, ending in a strongly pointed process which carries a relatively stout hair, and showing a secondary barb on its convex margin at about the apical third, the outer portion less heavily chitinised, pubescent on the basal half or two-thirds and of normal form, with the apex depressed and bearing a few small hairs. *Harpes*: basal portions rather broad, strongly chitinised, asymmetrical; from the right basal portion there arises a curved, heavily chitinised, blade-like structure which tapers to a point distally, and is prolonged posteriorly as far as the distal end of the main part of the side-piece; laterally the basal portions are produced into strongly chitinised bars which run diagonally backwards and join the end of the chitinised inner margin of the side-pieces. *Aedoeagus*: strongly chitinised, broad; the median transverse proximal portion with wing-like prolongations, the lateral portions each composed of a dorsal and ventral plate, the extremities divergent, pointed, resembling a pair of shears.

HABITAT: Accra, Gold Coast. Two males taken in the evening upon the windows of the laboratory, January and February, 1920.

Dasyhelea flava, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body (three specimens)	1·2 mm.	1·3 mm.
Length of wing	0·8 mm.	0·9 mm.
Greatest breadth of wing	0·2 mm.	0·3 mm.

Head yellow, the middle of the occiput brown. Eyes separated, narrowly in the female, more widely in the male. Clypeus yellow. Proboscis and palpi brown, the first segment of the palpi very small, the third segment inflated, about one-third longer than the fifth in the female; third segment of palpi in male cylindrical, less inflated than in the female. *Antennae* brown with dark hairs; in the female, segments four to ten bear stout sensory spines and are sub-spherical to oval in shape, the length varying from one to one and one-fifth the width, segments eleven to fourteen slightly longer, the last segment tapering to a narrowly rounded apex and almost one and three-quarter times

the length of the preceding segment; in the male, segments four to eleven oval to sub-oval in shape (almost hexagonal in transverse section), varying in length from two-thirds to one and a half times the width, last four segments gradually decreasing in length, twelve to fourteen, not binodose but exhibiting the usual sculpturing, with a basal whorl of hairs and shorter hairs distally, the last segment longest, longer than the twelfth, basally very broad and tapering to a pointed apex. *Thorax* canary yellow with three broad longitudinal brown bands: a median, which runs from the anterior margin to the posterior third of the dorsum and is frequently divided down its middle by a narrow yellow line, and lateral bands extending from the anterior fourth of the dorsum almost to the scutellum. In the male the thoracic pattern is less conspicuous, the yellow markings being contracted so that the general colour appears brown with yellow markings, rather than yellow with brown markings. Scutellum canary-yellow with four centro-marginal and two lateral black bristles, in both sexes; small hairs absent. Post-scutellum dark brown. Pleurae almost entirely canary yellow with small brown markings. *Wings* hyaline without spots, clothed with decumbent hairs which extend basally well beyond the cross-vein. Halteres canary-yellow in both sexes. *Legs* brown, rather lighter coloured in the male, the knees infuscated. Claws simple, bifid at the tips in the male. *Abdomen*: dorsum dark brown, venter somewhat tawny, especially towards the apices of the segments. Arising from the centre of the anterior margin of the eighth sternite in the female and extending forwards into the seventh segment is a blunt, chitinous and apparently tubular process (fig. 9, *a*); the lower laminae appear to arise from the anterior edge of the eighth sternite, but the upper laminae extend backwards internally almost to the edge of the segment. This structure is conspicuous in specimens which have been treated with caustic potash, but is largely obscured by pigment in carbolic preparations; even in dry specimens, however, a small portion of the lower plate can usually be detected near the middle of the anterior margin of the eighth segment. Spermatheca (fig. 9, *b*), single, moderately chitinised, sub-spherical to oval (44μ by 40μ) in shape with the beginning of the duct chitinised.

Hypopygium (fig. 10). *Ninth segment*: tergite broad basally, tapering distally, sparsely clothed with strong hairs, posterior margin

not notched and without finger-like lateral processes, sternite relatively narrow, with a conspicuous but not heavily chitinised median pincer-like process projecting backwards ventral to the aedoeagus. *Forceps*: side-pieces short and stout, broader apically than basally, rather scantily clothed with moderately long hairs; claspers bifid, highly chitinised, antler-like, the inner branch pointed and bearing two setae a little beyond the middle, the outer branch strongly curved, pointed, with a prominent seta near the base. *Harpes*: basal portions articulating with the base of the side-pieces,

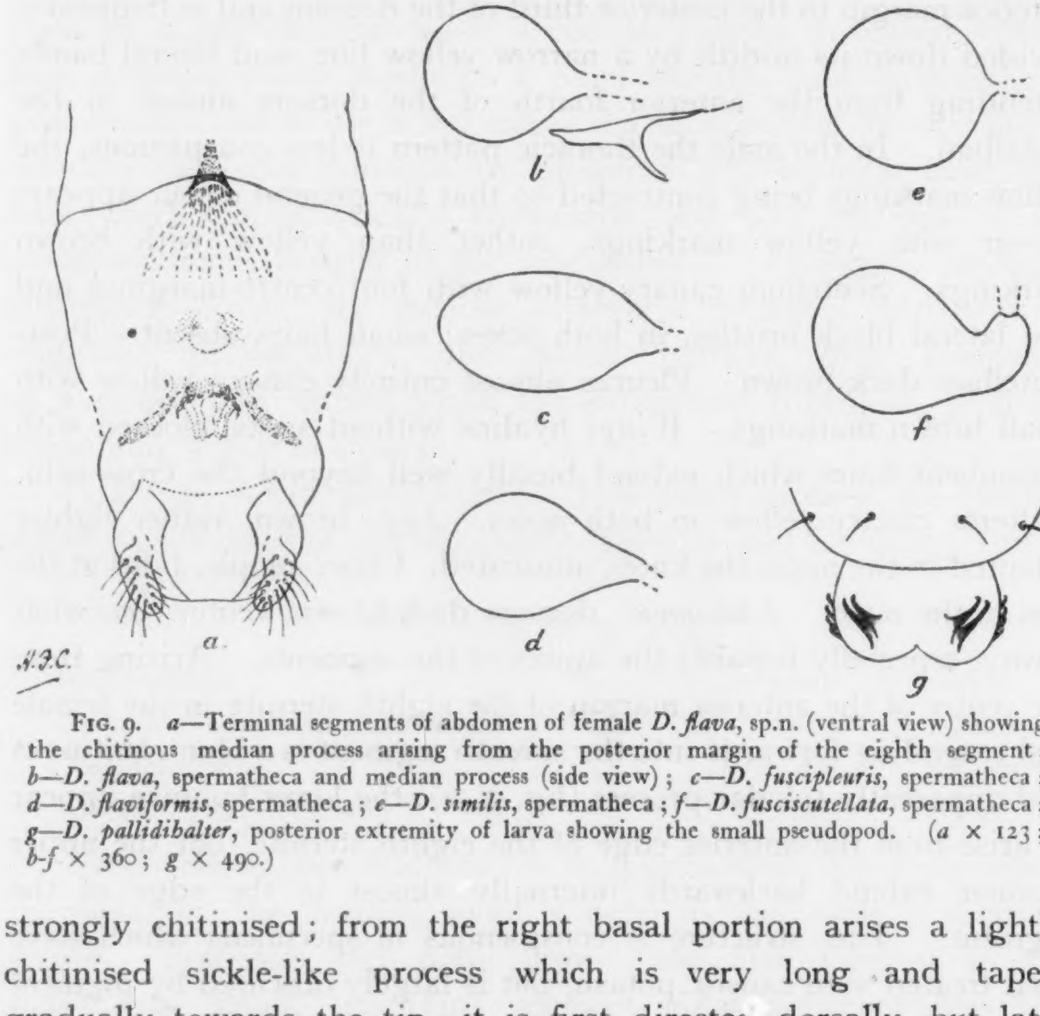

FIG. 9. *a*—Terminal segments of abdomen of female *D. flava*, sp.n. (ventral view) showing the chitinous median process arising from the posterior margin of the eighth segment; *b*—*D. flava*, spermatheca and median process (side view); *c*—*D. fuscipleuris*, spermatheca; *d*—*D. flaviformis*, spermatheca; *e*—*D. similis*, spermatheca; *f*—*D. fusciscutellata*, spermatheca; *g*—*D. pallidibalter*, posterior extremity of larva showing the small pseudopod. ($a \times 123$; b-$f \times 360$; $g \times 490$.)

strongly chitinised; from the right basal portion arises a lightly chitinised sickle-like process which is very long and tapers gradually towards the tip—it is first directed dorsally, but later curves strongly in a ventral direction and distally is covered with delicate spicules. *Aedoeagus*: a broadly-ending gutter-like structure tapering but slightly from base to apex, the median transverse portion and the lateral portions heavily chitinised.

PUPA. Length (two specimens) 1·7 mm. *Respiratory trumpets* long, narrow and curved, arising from small tubercles; length about

0·2 mm. Distal extremity not infuscated, slightly broadened and without rings, middle portion irregularly ringed, base slightly constricted; lateral openings of the tracheal trunk occur from base to apex, about six being situated near the tip. *Cephalothorax*: anterior marginal tubercles large, conical, heavily shagreened, bearing a very short bristle. In the middle line between the anterior marginal tubercles is an antero-posterior row of three

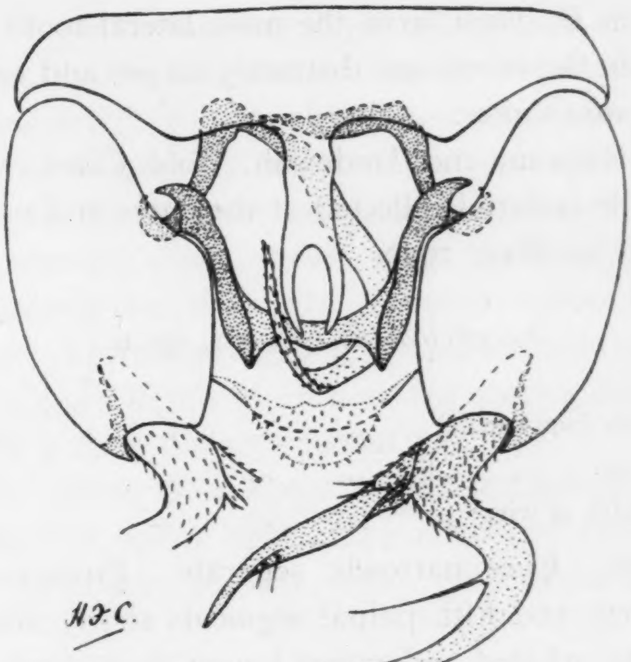

FIG. 10. *D. flava*, sp.n., male hypopygium (ventral view). × 400 circa.

unarmed somewhat heavily shagreened tubercles, the most anteriorly placed being slightly ventral, the middle one slightly dorsal, to the marginal tubercles. Anterior dorso-median tubercle represented by two or three small hairs; dorso-lateral tubercle somewhat prominent, irregularly shaped and bluntly rounded, bearing a moderately long and a short hair; ventro-lateral tubercle bearing a minute hair; ventro-median tubercle represented by a small hair. The ventral surface also bears small, highly chitinised, unarmed tubercles, one on each side of the middle line near the centre of the cephalic region. *Abdomen* more heavily shagreened than, but otherwise similar to, that of *D. pallidihalter*.

LARVA. Adults of this species were reared from larvae obtained from banana fibre which had been isolated in small tubes; the larval

pelts were not subsequently found, but as no other species of *Dasyhelea* was reared from this particular sample of banana fibre in the course of some weeks' observation, the *Dasyhelea* larvae found therein have been ascribed to *D. flava*.

Length (three specimens) 2·9 mm.; greatest breadth 0·2 mm. *Head*: length 0·18 mm., greatest breadth 0·12 mm. These larvae are almost indistinguishable from those of *D. pallidihalter*, the only apparent difference being in the size and form of the teeth on the mental plate, in *D. flava* larva the most lateral tooth on each side is smaller, while the others are distinctly larger and coarser than in larvae of *D. pallidihalter*.

HABITAT: Nsawam and Dodowah, Gold Coast. Reared from rotting vegetable material collected at the bases and roots of banana plants, January to May, 1920.

Dasyhelea fuscipleuris, sp. n.

MEASUREMENTS.

Length of body (one female)	1·2 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·4 mm.

Head brown. Eyes narrowly separate. Proboscis and palpi brown, the fourth and fifth palpal segments short, sub-equal, third segment slightly inflated and rather longer than the fourth or fifth. Antennae brown; segments four to ten inclusive sub-spherical to broadly oval in shape, in length from four-fifths to one and one-quarter times the greatest width, segments eleven to fourteen oval and in length about one and a quarter times the greatest width, the fifteenth slightly longer and about twice as long as wide. *Thorax* yellow, becoming yellowish-brown posteriorly in front of the scutellum, with broad brown or blackish-brown median and lateral bands; the median band, which has a shining appearance in certain lights, is of almost uniform width and extends from the anterior margin to about the middle of the thorax, the lateral bands are broad and rounded anteriorly, gradually narrowing posteriorly, and extend from the anterior fourth of the thorax almost to the scutellum; each lateral band near the middle of its outer border gives off a narrow dark stripe which is directed forwards and ends a short distance behind the antero-lateral angle. Scutellum entirely pale

yellowish-brown with three or four centro-marginal and two lateral bristles; short hairs absent. Post-scutellum dark brown. Pleurae almost entirely yellowish-brown with a few small darker brown markings. *Wings* hyaline, sparsely clothed with decumbent hairs which scarcely extend basally beyond the cross-vein and in the anterior apical portion are almost confined to the margin and to the fold above the upper branch of the fourth vein. The costa extends slightly beyond the middle of the wing and distinctly beyond the bifurcation of the fifth vein; the single cell between the first and third veins distinct, rather longer than broad. Halteres yellow-brown. *Legs*: distinctly light brown with the extreme bases of all the tibiae and the apices of the hind tibiae very dark brown; the fifth tarsal segments of all the legs are somewhat infuscated. Claws simple. *Abdomen*: dorsum dark brown, with the hind margins of the segments narrowly but distinctly yellowish; venter of a rather pale brown colour. Spermatheca (fig. 9, *c*) single, oval to pyriform (average about 61 μ by 42 μ), highly chitinised, the commencement of the duct chitinised for a short distance (about 8 μ).

HABITAT: Accra, Gold Coast. Two females taken on the arm, one in a bungalow near a light at 9 p.m., April 18th, 1920, and the other in the laboratory in May, 1920. Numerous specimens (♀♀) bred later.

A yellowish-brown midge somewhat resembling *D. flava* in appearance, though less brightly coloured.

Dasyhelea flaviformis, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·0 mm.	1·0 mm.
Length of wing	0·6 mm.	0·7 mm.
Greatest breadth of wing	0·2 mm.	0·2 mm.

Head brown with lighter brown borders round the eyes and occiput. Eyes narrowly separate. Proboscis and palpi brown, third segment of the palpi not swollen, longer than the fourth and about as long as the fifth segment. *Antennae* brown with dark brown hairs; segments four to ten in the female with curved spines, sub-spherical, as broad as long, segments eleven to fourteen rather longer than broad, the terminal segment the longest, being two and a half times as long as broad and almost twice as long as the

preceding segment; the last four segments of the male elongate, segments twelve to fourteen binodose. *Thorax* tawny-yellow with broad, longitudinal, brown bands arranged in much the same pattern as those of *D. flava* and of *D. fuscipleuris*: a broad median band, divided by a narrow, median tawny stripe extends almost from the anterior margin to the posterior third of the dorsum, and lateral bands, one on either side, extend from the anterior third of the dorsum almost to the scutellum. Scutellum tawny-brown with slightly darker brown sides, carrying three central and two lateral bristles in both sexes; short hairs absent. Post-scutellum dark brown. Pleurae tawny with two or three dark brown markings. *Wings* hyaline; decumbent hairs rather more scanty than in *D. flava*, extending basally between the fourth and fifth longitudinal veins to about the point of separation of the first and third longitudinal veins, the anal cell bare and the anterior apical region rather more sparsely clad. Halteres with brown stems and cream-coloured knobs. *Legs*

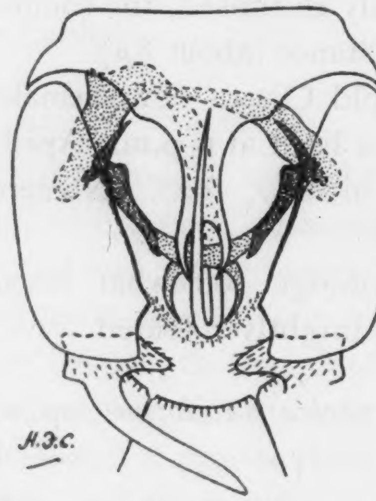

FIG. 11. *D. flaviformis*, sp.n., male hypopygium (ventral view). × 400 circa.

almost uniformly light brown, with dark knee spots. Claws simple and equal. *Abdomen* dark brown; in the female there are semi-lunar tawny markings on either side of the middle line on the dorsum of the fifth, sixth and seventh segments, and the apex of the abdomen is pale; in the male entirely dark, except for small paler lateral spots on the first and second segments. Spermatheca (fig. 9, *d*) pyriform (length 43μ, breadth 35μ), moderately highly chitinised, the commencement of the duct chitinised.

HYPOPYGIUM (fig. 11) resembling that of *D. flava*. *Ninth segment*: tergite broad basally, narrowing slightly towards the

apical margin which is not notched, finger-like lateral processes rudimentary but bearing a single rather long stout hair; sternite with the median, pincer-like extension well developed. ***Forceps***: side-pieces relatively longer than in *D. flava*, claspers more slender and less curved, and bearing a rudimentary, conical, second branch on their inner sides basally, the basal portion only pubescent. *Harpes* similar to those of *D. flava* but relatively larger and stouter; the sickle-like structure arising from the right basal process is very long and strongly curved, and apically is devoid of spicules. *Aedoeagus* differs from that of *D. flava* in that the distal extremity gives off two curved chitinous processes, one on either side of the middle line, resembling a pair of forceps.

PUPA. Length about 1·5 mm.; somewhat infuscated at the anterior end, integument shagreened. *Respiratory trumpets* (fig. 3, *b*): length about 0·15 mm.; breadth about 15μ. They are infuscated apically, and are long, narrow and curved, arising from slight papillae; the main tracheal trunk begins to give off lateral branches just above its base, the first four widely separate but those near the tip more closely situated, together forming a series of nine or ten branches. The trumpets are irregularly ringed in the middle and show no definite tubercles. *Cephalothorax* infuscated anteriorly; operculum dark, highly chitinised and coarsely shagreened, with two low and rounded, but relatively large, elevations in the middle line. Anterior marginal tubercle well-developed, conical, bearing a very small seta; dorso-lateral tubercles well-developed, bearing several minute hairs; anterior dorso-median tubercle almost indistinguishable, being represented by a few minute hairs; ventral tubercles undeveloped, represented by minute hairs. Dorsum of thoracic region infuscated, without tubercles but with numerous macules. *Abdomen* exhibiting no peculiarities, of the usual pattern but rather poorly chitinised.

HABITAT: Oblogo, Gold Coast. Reared from rotten wood taken from a canoe in the river Densu, May, 1920. The pelt of a larva which had been isolated in a tube with a piece of the rotten wood in which it was found and from which a pupal pelt and an adult of this species were obtained, was not recovered.

A small brown midge resembling in markings *D. flava*, but with the lighter coloured areas a dull tawny-yellow in place of brilliant canary-yellow.

Dasyhelea fusca, sp. n.

MEASUREMENTS.	Female.	Male.
Length of body	1·5 mm.	1·6 mm.
Length of wing	1·1 mm.	1·3 mm.
Greatest breadth of wing	0·4 mm.	0·3 mm.

Head brown with brown hairs. Eyes broadly contiguous in the female, narrowly separate in the male. Proboscis pale brown. Palpi brown, third segment slightly swollen, distinctly shorter than the fourth and fifth segments together. *Antennae* in the female brown, torus much darker than the segments of the flagellum, with dark hairs and large, curved spines (in addition to short blunt spines) on all the segments; segments four to eleven sub-spherical to oval, constricted apically, the last segment elongate, at least one and a half times as long as the penultimate, with a distinct stylet. In the male, strongly plumose, the whorl hairs dark brown; segments three to eleven spheroidal, segments twelve to fourteen elongate, strongly binodose; last segment stout and cylindrical, with a conspicuous stylet. *Thorax* dark brown with paler brown to yellowish areas at the anterior lateral angles and bases of the wings (in fresh specimens the dorsum is greyish-pruinose), sparsely clothed with dark brown hairs. Scutellum pale yellowish-brown with five or six centro-marginal and two lateral bristles, and about six (four to seven) short median hairs. Post-scutellum and pleurae dark brown. *Wings* almost unicolourous but slightly infuscated at the junction of the first and third veins and costa; surface rather thickly clothed with long hairs, which extend basally beyond the cross-vein. First and third veins fused, extending for a considerable distance parallel to the costa and joining the latter well beyond the middle of the anterior border and the bifurcation of the fifth vein. Halteres with cream-coloured knobs. *Legs* light brown, the knees slightly darker, the apices of the tarsal segments infuscated, fore and hind femora each with a dark spot above the apex. Claws simple, bifid distally in the male. *Abdomen* dark brown with brown hairs, which are most numerous at the sides and on the distal segments. Spermatheca more or less pyriform (length 61 μ, breadth 45 μ) in shape and feebly chitinised.

HYPOPYGIUM (fig. 12). *Ninth segment*: tergite with moderately long hairs dorsally, broad, gradually tapering towards the posterior

margin, the finger-like processes well developed, dark, each with a stout hair at the apex and a group of five or six shorter hairs at the base; sternite relatively broad, without a central posterior projection. *Forceps*: side-pieces short and broad, clothed with short, stout hairs; claspers pubescent, rather longer than the side-pieces, the tips slightly rounded and bearing a few minute hairs. *Harpes*: basal portions somewhat asymmetrical, large, strongly chitinised, curving forwards towards their junction near the middle line; distal portion

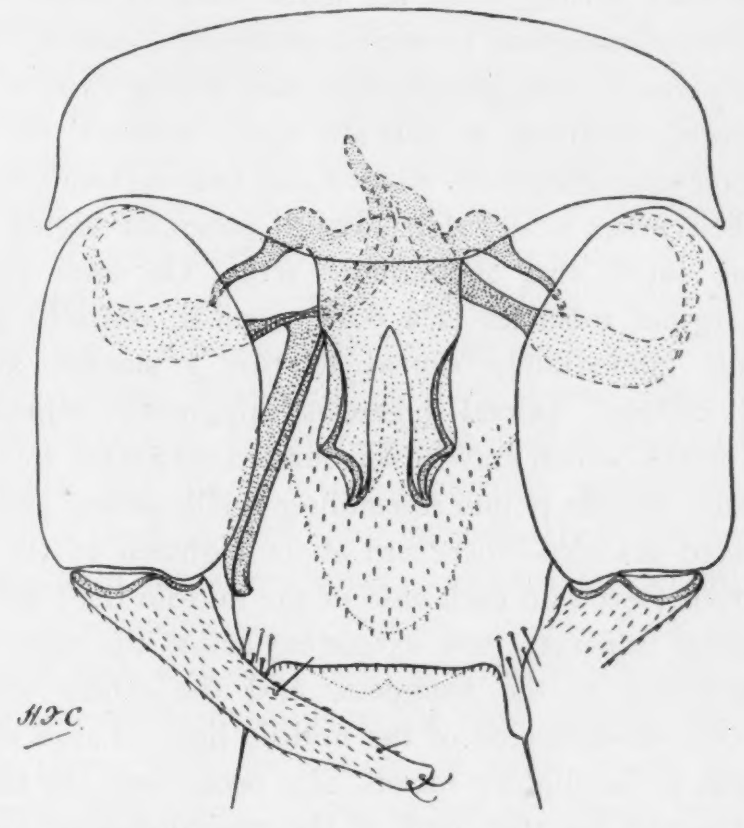

FIG. 12. *D. fusca*, sp.n., male hypopygium (ventral view). × 400 circa.

of the right harpe in the form of a stout, strongly chitinised, blade-like structure with a pointed, slightly re-curved apex, extending posteriorly almost as far as the posterior margin of the ninth tergite. *Aedoeagus* large, projecting posteriorly to about the level of the middle of the side-pieces, broad basally, narrowing slightly apically as shown in fig. 12.

PUPA. Length 2·3 mm.; relatively large and well chitinised, with the cephalo-thoracic portion slightly infuscated and with

characteristic, loofah-like, trumpets. Integument shagreened, especially over the middle of the anterior part of the cephalothorax and on the last abdominal segment. *Respiratory trumpets* (fig. 3, *d*): length about 0·3 mm., broad and flat, arising from small tubercles; the basal third cylindrical, dark coloured, annulated, the apical two-thirds expanded and flattened, with very numerous tracheal branches arranged somewhat like the leaflets of a long pinnate leaf which has been doubled upon itself so that the fold is at the distal end and the base and tip at the proximal end—the branches are apparently double processes arising from the main tracheal trunk. *Cephalothorax*: anterior marginal tubercles prominent, conical, divergent, covered with coarse dark granulations and ending each in a double-pointed process bearing a delicate hair; anterior dorso-median tubercles somewhat irregularly shaped and bearing small and delicate setae on their inner sides; dorso-lateral tubercles highly granular, bearing one small and one minute seta. On each side of the anterior marginal tubercles is a dark, conical, coarsely granulated nodule, and immediately dorsal to this a smaller and flatter granulated nodule. Dorsal tubercles apparently represented by socket-like marks (which may be surrounded by a dark zone and may show centrally minute points resembling small spines) and by small dark puckered macules—there are about eighteen of the latter, of which fourteen (seven on each side of the middle line) are arranged in an irregular transverse row extending across the dorsum a short distance posterior to the trumpets, and the others are situated anteriorly two on each side of the middle line. Large dark areas, which appear to be slightly raised, also occur over the bases of the wing sheaths and on that part of the cephalothorax immediately posterior to them, and other macules may be distinguisned on the posterior portion of the dorsum. *Abdomen*: tubercles poorly developed; on both surfaces of each segment, but more conspicuous on the dorsum, are three rounded and darkened macules arranged in the form of an equilateral triangle with its apex posteriorly directed.

HABITAT: Oblogo, near Accra. Pupae and pupal pelts were found in stagnant water contained in canoes which were tied to the bank of the river Densu; and pupae in the rotten wood forming the sides and ends of these canoes. Larvae were not obtained.

Dasyhelea nigrofusca, sp. n.

MEASUREMENTS.	Male.
Length of body	1·5 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·3 mm.

Head dark brown, almost black. Eyes broadly contiguous dorsally. Proboscis and palpi dark brown, the third segment of the palp distinctly swollen and rather longer than the fourth or fifth, which are sub-equal in length. *Antennae* dark brown with almost black hairs; segments four to eleven more or less hexagonal, in length from three-fourths to rather more than once the width, segments twelve to fourteen elongate, binodose, decreasing in length from about three times to two and a half times the width, terminal segment broad, rather shorter than the twelfth segment and with a small apical stylet. *Thorax* dark greyish-pruinose with sepia markings, the lateral margins narrowly yellowish; scantily clothed with dark hairs. Scutellum dark brown in the middle, yellow laterally, with a row of eight sub-marginal bristles and about half a dozen median short hairs. Post-scutellum dark brown. Pleurae yellow with dark brown markings. *Wings* hyaline, well clothed with decumbent hairs. First and third veins apparently completely fused, the bifurcation of the fifth vein lying immediately below the apex of the costa. Halteres brown with paler coloured but slightly infuscated knobs. *Legs* conspicuously banded, femora dark, slightly paler basally and with a distinct pale band before the apex, knee joints dark, tibiae with dark bands at the base, middle and apex, tarsal segments paler, with indications of dark bands at the apices; clothed with dark hairs. Claws simple and equal, bifid at the tips. *Abdomen* sepia-coloured, clothed with dark brown hairs; venter yellowish.

HYPOPYGIUM (fig. 13). *Ninth segment*: tergite scarcely tapering, the posterior margin straight, the finger-like processes well developed, each bearing a single hair and with a prolongation of the tergite connected with them dorsally; sternite without a central posterior extension. *Forceps*: side-pieces of the usual form; claspers as long as the side-pieces, the basal halves pubescent and carrying two short hairs near the middle and three or four short hairs near the apex. *Harpes*: basal portions strongly

chitinised and bent in an anterior direction, that of the right side being shorter and more abruptly bent and articulating with a double curved, blade-like distal process; the latter is very long and reaches posteriorly as far as the apices of the side-pieces, it is broader in the middle than at either extremity, and is serrated at the apex. *Aedoeagus* broad basally, narrowing somewhat apically, the distal portion consisting of two highly chitinised hook-like rods on either side connected by a ventral wall of thin chitin; these lateral rods are not on the same plane, and the ventral pair are longer, less sharply bent medially, and notched at the ends.

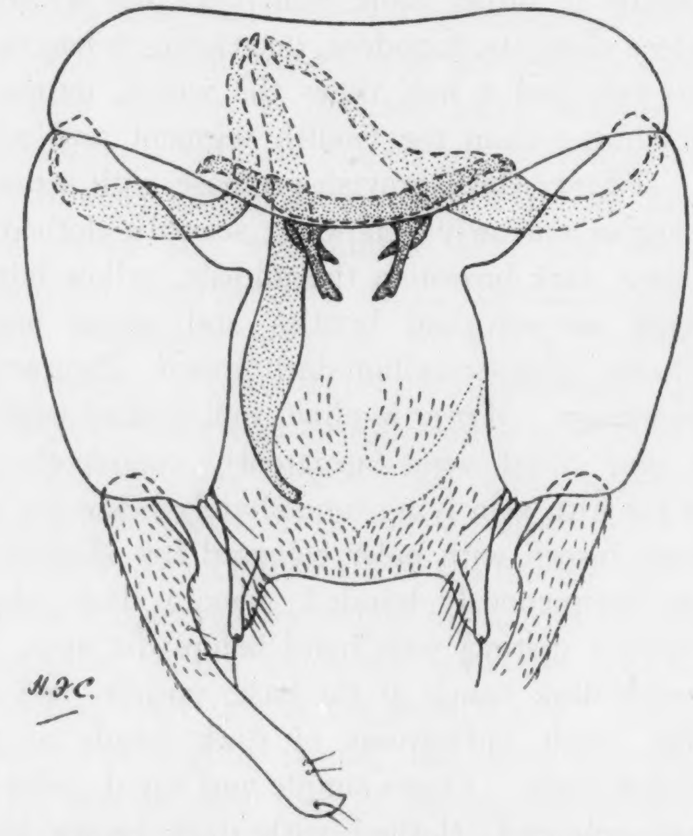

FIG. 13. *D. nigrofusca*, sp.n., male hypopygium (ventral view). × 400 circa.

PUPA. Length 2·6 mm.; shagreened but not highly chitinised. *Respiratory trumpets* (fig. 3, *c*): length about 0·1 mm., short, broad and constricted at the base, arising from small tubercles and with the basal half covered with minute squamose spines; lateral processes (numbering about twenty) of the tracheal trunk given off at regular intervals—at first in a single, later in a double row, extending from a short distance above the base to the apex. *Cephalothorax*: spines and tubercles poorly developed; operculum

wanting. Anterior marginal tubercle small, bearing a small bristle; dorso-lateral tubercle bearing two small hairs; anterior dorso-median tubercle very small with two hairs; ventro-median tubercle minute, bearing a small hair; ventro-lateral tubercle represented by two or three small hairs. Dorsum of the thoracic portion without tubercles or spines. *Abdomen*: integument with transverse cellular sculpturing and minute spicules basally and laterally; these spicules are most numerous and most highly developed on the last segment and its terminal processes. The segments are furnished with the usual backwardly projecting shelf-like tubercles, those forming the ventro-lateral series being the most prominent.

HABITAT: Dodowah, Gold Coast (north-east of Accra), reared from materials collected from a rot-hole in a mango tree, March 7th, 1920. The larva was not identified.

Dasyhelea fusciformis, sp. n.

MEASUREMENTS.	Female.
Length of body	1·3 mm.
Length of wing	1·1 mm.
Greatest breadth of wing	0·3 mm.

Head brown with brown hairs. Eyes very narrowly separate, almost contiguous. Clypeus, proboscis and palpi brown; all segments of the latter somewhat swollen, the third cylindrical, longer than the fourth and fifth segments together, the fifth much shorter than the fourth. *Antennae* brown with brown hairs and long curved spines on all the segments; segments of the flagellum sub-spherical to oval in shape, each with an apical constriction, the last segment elongate with a distinct stylet (fig. 2, *a*). *Thorax* dark brown with dark hairs, the anterior-lateral angles and areas at the bases of the wings paler brown. Scutellum light brown with eight centro-marginal and two lateral bristles, and three short hairs. Post-scutellum and pleurae dark brown. *Wings*: decumbent hairs extending to the base of the wing between the fourth and fifth veins; costa reaching the middle of the anterior border and terminating beyond the bifurcation of the fifth vein, the first and third veins distally forming a small cell. Halteres with cream-coloured knobs and dark brown stems. *Legs* uniformly brown, the claws simple. *Abdomen* dark brown, lighter coloured distally, with dark brown hairs.

Spermatheca sub-spherical (length 53μ, width 48μ), moderately chitinised, the duct wide at its origin, tapering gradually and chitinised for a very considerable portion (50μ) of its length.

PUPA. Length 2 mm., moderately well chitinised, the integument shagreened and the last abdominal segment with small spicules. *Respiratory trumpets*: length about 0·17 mm., breadth 0·03 mm., rather short, broad and almost straight, with a slight basal constriction and with the surface covered with minute, imbricated, flattened spines. The tracheal trunk gives off three or four lateral branches at regular intervals in the basal three-fourths of the trumpet, and a series of about a dozen close together in the apical fourth. *Cephalothorax*: anterior marginal tubercles wanting —the operculum missing from the single pelt examined; anterior dorso-median tubercle poorly developed, bearing a single small hair; dorso-lateral tubercle small, carrying two short hairs; ventro-lateral tubercle indistinguishable; ventro-median tubercle represented by two small hairs. Integument of the dorsum of the thoracic portion with puckered macules, but without tubercles. *Abdomen* with tubercles of the usual type and arrangement.

The pupal stage is apparently short, as the adult insect appeared on the fourth day after isolating the larva. The pupal pelt was found with the cephalothorax protruding from a piece of rotten wood.

LARVA. A single larva of this species was collected and isolated in a small tube; it was rather large, with well-formed hooks at the posterior end of the abdomen. Its movements were slow and deliberate and it was observed to crawl up the sides of the glass vessel in which it was contained, but afterwards it quickly buried itself in the rotten wood and was not seen again. After the insect had hatched the pupal pelt was secured, but the only portion of the larval pelt found was the head; this was dark-coloured and heavily chitinised, and measured 0·3 mm. in length and 0·2 mm. in greatest width.

HABITAT: Oblogo, Gold Coast. Reared from materials collected from a rot-hole in a tree (*Cynometra* sp., probably *C. megalophylla*, Harms.), May, 1920.

D. fusciformis is a brown midge closely resembling *D. fusca*, but smaller in size and with the colouring of the scutellum and the lighter

patches on the thorax pale brown rather than yellow. The spermathecae and pupae of these two species are quite distinct.

The species of *Dasyhelea* described above may be separated as follows :—

FEMALES

1. Antennal segments sub-spherical or oval, not constricted apically, the last segment not produced into a stylet ; scutellum with at most four centro-marginal bristles 2

   Antennal segments constricted apically, the last with a distinct stylet ; scutellum with at least five centro-marginal bristles ... 9

2. Species mainly dark brown in colour 3

   Species yellowish with dark brown markings 7

3. Scutellum dark brown, at most with the central portion yellowish... 4

   Scutellum entirely yellowish 6

4. Scutellum yellowish in the middle ; halteres white, *pallidihalter*, sp. n. (p. 184)

   Scutellum entirely dark brown ; halteres yellowish 5

5. Spermatheca reniform ; claws with a distinct sub-central projection ... ... *fusciscutellata*, sp. n. (p. 187)

   Spermatheca spherical ; claws without a distinct sub-central projection ... ... *similis*, sp. n. (p. 189)

6. Scutellum bright yellow ; halteres white ... *luteoscutellata*, sp. n. (p. 191)

   Scutellum yellowish-brown ; halteres yellowish-brown ... ... *inconspicuosa*, sp. n. (p. 191)

7. Species bright yellow ; the eighth abdominal segment with a ventral backwardly directed chitinous process ... ... *flava*, sp. n. (p. 196)

   Species dull yellow ; the eighth abdominal segment without such a process 8

8. Larger species (wing length 1·0 mm.) ; halteres yellowish-brown ; hind margins of abdominal segments narrowly yellowish ... ... *fuscipleuris*, sp. n. (p. 200)

   Smaller species (wing length 0·7 mm.) ; halteres cream-coloured ; semilunar tawny markings on dorsum of fifth, sixth, and seventh abdominal segments ... ... *flaviformis*, sp. n. (p. 201)

9. Spermatheca pyriform, feebly chitinised ; scutellum with five or six centro-marginal bristles ... ... *fusca*, sp. n. (p. 204)

   Spermatheca spherical, moderately chitinised, with a very long posterior extension ; scutellum with eight centro-marginal bristles ... ... *fusciformis*, sp. n. (p. 209)

MALES (separation on hypopygial characters)

1. Claspers single 2
   Claspers double 6

2. Ninth sternite with a central posterior extension 3
   Ninth sternite without a central posterior extension 4

3. Posterior extension of ninth sternite large, ob-ovate ... ... *pallidihalter*, sp. n. (p. 184)
   Posterior extension of ninth sternite smaller, somewhat rectangular ... ... *fusciscutellata*, sp. n. (p. 187)
   Posterior extension of ninth sternite cone-like *inconspicuosa*, sp. n. (p. 191)

4. Distal portions of harpes fused, forming a single median process ... ... *similis*, sp. n. (p. 189)
   Distal portion of one harpe only developed 5

5. Aedoeagus relatively short, reaching about one-third the length of the side pieces; distal fourth of the harpal process attenuated, the apex serrated ... ... *nigrofusca*, sp. n. (p. 207)
   Aedoeagus long, reaching beyond the middle of the side pieces; harpal process not attenuated distally, the apex pointed ... ... *fusca*, sp. n. (p. 204)

6. Inner portion of clasper small, conical ... *flaviformis*, sp. n. (p. 201)
   Both portions of clasper large and well developed 7

7. Central posterior extension of the ninth sternite cone-like ... ... *nigricans*, sp. n. (p. 194)
   Central posterior extension of the ninth sternite pincer-like ... ... *flava*, sp. n. (p. 196)

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THE PREVALENCE AND CHARACTER OF TUBERCULOSIS IN HONGKONG

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I. GENERAL CONSIDERATIONS

The statement has been made that not only is tuberculosis a common disease in the tropics, but that it appears to be increasing in its ravages in the East. Seeing that the treatment of tuberculosis, both prophylactic and curative, consists largely in fresh air and sunshine, it seems strange that this disease should be rife in tropical countries where sunshine is so prevalent and living in the open air is the rule.

A very brief experience as medical officer in charge of the mortuary sufficed to show that tuberculosis was a frequent cause of death in Hongkong, and I deemed it an investigation well worth undertaking to determine the varieties of the disease as met with here, the portals of entry, the mode of spread, and, if possible, to determine the primal cause or causes responsible for the condition and those aiding its dissemination, with a view to elucidating measures for its prevention.

I have excluded those cases which showed merely signs of old-standing tuberculosis, for previous investigations have proved that after middle life nearly all bodies yield evidence of some healed focus of the disease. A particularly noticeable feature in my series is the large percentage of children of tender age who die from tuberculosis. Another point worthy of note is the fact that whereas at home intestinal tuberculosis as a primary condition is fairly common in children and is ascribed to the drinking of infected milk, in tropical countries primary intestinal tuberculosis is met with although milk

is not taken as a regular food; this holds good here also, though it is only right to add that primary intestinal infection appears to be comparatively rare in Hongkong.

Before proceeding to speak in detail of the cases dealt with in this investigation, it will not be out of place to make a few general remarks on the disease. As is well known, the bacillus may persist for a long time in dust, in dried sputum, in urine, and so forth. When one sees how large a number of patients exhibit signs of tuberculosis after death, several of whom showed no marked signs during life, and when, as we know, the bacilli are shed broadcast not only in the sputum but in the fine spray of coughing and sneezing consumptives, the opportunities for the organism to gain entrance and to propagate are many. Thus, the bacillus has been found in the sweepings of rooms (Manfredi at Naples, Marpmann at Leipzig), on fruit exposed for sale (Schnirer), in the wards of hospitals (Strauss, Le Noir), in books, in the bodies of flies (Nuttall, André), on clothes (Josephson, Nötel, Chaussé), as quoted by Etienne Burnet: 'Ou trouve comme une quintessence des poussières atmosphèriques dans ces poussières fines que l'on pompe par le vide (vacuum cleaner); avec elles s'est déposé ce qu'il y a de plus léger dans ce que soulèvent nos semelles et l'intense circulation de nos rues, et ce que crache une population malheureusement trop insouciante.'

As stated by Delépine, the difficulties of elucidating the causes of an infectious disease depend on the fact that we must take account of the various ways in which the predisposing and determining factors have combined in their action, and the difficulties are increased when we attempt to assign to each its appropriate share. He groups these factors under the following heads: (1) Distribution and habits of the pathogenic organism. (2) Conditions influencing its number. (3) The pathogenicity and toxicity of it, or, in other words, the conditions influencing its virulence. (4) The opportunities which the organism may have of gaining access to one or more channels of infection. (5) The conditions influencing the resistance which any possible host may be capable of opposing to the attacks of the organism. (6) The frequency and degree of completeness of recovery from occult or manifest infection. This comes into play more with regard to the question of adult tuber-

culosis, whereas the present investigation is concerned with the disease as found in children.

Of these factors those of special importance are the number and virulence of the organism on the one side and the degree of resistance which the subject attacked may be able to oppose on the other.

There appears to be no doubt that the resistance set up, if not adequate for the destruction of the organism, even contributes indirectly to an increase in the virulence of the latter. Thus, an organism, *e.g.*, the ***Bacillus tuberculosis*** of reduced virulence in milk, after inoculation was found to gain in virulence according as the distance from the site of inoculation increased. The resistance offered to the invading organism being insufficient to destroy it, trained it, as it were, to develop more inimical powers of attack, so that, as the bacilli overcame successively the barriers placed in their path, they increased not only in virulence but in number also, just as the *Virus fixe* of rabies was obtained by Pasteur by means of passage of the street virus through a series of animals. This process has been designated a 'reinforcement by relays.' The overcoming of this resistance by an organism of feeble aggressive powers of course takes time whether the delay is caused by the small number of organisms, or by their being of reduced virulence, or by the greater degree of resistance set up leading to a 'relatively reduced virulence.' One or other of these, acting singly or in combination, may be adduced to account for latency.

Where cases are met with in which death occurs at such a tender age as 22 days (No. 128),* 24 days (No. 214), 29 days (No. 180), and 7 weeks (Nos. 63 and 114), one is naturally led to enquire into the question of congenital and hereditary tuberculosis.

The possible modes of congenital infection are, of course, either by the ovum or spermatozoon, or via the placenta from a tuberculous mother. As regards the first of these, as Adami states, 'the microbe of an infectious disease cannot be a constituent of the biophore. At most it can be an accidental inclusion in the surrounding non-heritable matter of the cell.' The human ovum, being practically

* The serial numbers refer to those contained in a table showing the post-mortem findings of the 300 cases of tuberculosis under consideration. The Editors regret that it is not possible to reproduce this table.

free from yolk and not being phagocytic, cannot take up the bacilli, while it is still more improbable that the minute spermatozoon could carry them. Repeated observations go to show that the semen of a phthisical patient (Rohlff, Gaertner) does not contain as many as ten bacilli, and as the average human seminal ejaculation is said to contain over 200 million spermatozoa, the chances that a single spermatozoon which fertilises the ovum should carry a bacillus are about one to twenty million. For practical purposes this mode of infection may be regarded as impossible. The second method, via the placenta of a tuberculous mother (or perhaps through the walls of the foetal sac, or passing to the foetus before the sac forms), has been shown to be possible; in fact, intra-uterine acquirement of disease as distinct from inherited disease is proved. Such transmission of the tubercle bacillus from parent to child *in utere,* is however, undoubtedly very rare. Thus Schluster, who examined into the records of the reported cases, as mentioned by Latham, was able to collect only twelve showing clinical evidence of tuberculosis at birth. Furthermore, in the majority of instances, the organs of foetuses born of tuberculous mothers yield only negative results when inoculated into guinea-pigs.

The theory of diathesis—the question as to whether the children of tuberculous parents suffer from a greater liability to tuberculosis from enhanced susceptibility resulting from 'paratuberculous lesions' due to toxic action on the germ cells—the hereditary transmission of constitutional predisposition to tuberculosis, is being relegated more and more to the realms of improbability as modern knowledge, with its insistence on accuracy of detail, demands facts and proofs in place of nebulous hypotheses.

The dominating factor in the incidence of tuberculosis is the opportunity for infection; in other words, the greater the opportunity for infection the greater is the incidence and the mortality from this disease. Can we argue that the reverse of this also holds good, namely, that a high incidence and mortality mean greater opportunities for infection? Probably we can, as will be shown later when the local conditions are mentioned.

It would appear to be established that under certain circumstances, no matter what the 'diathesis' may be, infection can always be effective. To prove that some children inherit a predisposition

to tuberculosis, the incidence of the disease amongst the offspring of tuberculous parents and amongst equal numbers of non-tuberculous parents would have to be compared, and, furthermore, it would be essential that both should be subjected to the same environment from birth, as McFadyean has pointed out. Even then we must bear in mind the fact that the former will have been exposed to infection during the intra-uterine period, so that the conditions for comparison will not be strictly impartial. To compare, as has been done, the death-rate from tuberculosis amongst members of the two categories—the children of healthy parents on the one hand and those of tuberculous parents on the other—is fraught with fallacy, as the after conditions are so diverse. To make them more equable it would be necessary for the children of healthy parents to be born in infected houses or be placed there at birth, clearly an impossible condition except by mere accident.

The children of tuberculous parents are thus handicapped in several ways, each of which plays a part in rendering fallacious the comparison of their death-rate with that among children of healthy parents. The chief of these disturbing factors would be: (1) Intra-uterine exposure. (2) Birth in infected surroundings, and, therefore, greater liability to infection while young. (3) The dose of infecting material is likely to be large. (4) This dose is probably frequently repeated.

That the intra-uterine period may be dangerous to the child from the point of view of tuberculosis has been definitely proved, though the cases on record are very exceptional. Thus Schmorl and Birch-Hirschfeld, and Schmorl and Kockel, have described cases in which the bacilli were found in the placentae and the foetuses of tuberculous mothers. More recently Friedmann reported the finding of two cases of tuberculous infection by the placental route.

So much for the question of hereditary transmission of the *Bacillus tuberculosis*. As regards environment no one now disputes the importance of this factor in producing the disease, but though comparison is difficult in human beings owing to the variety of disturbing factors, as has already been stated, in animals we can better arrange conditions to suit our purpose. The experiments of Trudeau may be referred to in this connection. He inoculated

rabbits with tuberculosis and allowed some to run wild, whereas others were kept in a damp, dark place. Most of the former recovered, while the latter rapidly succumbed.

In cattle an analogous condition is found. As McFadyean states: 'All breeds and strains of cattle are susceptible to tuberculosis, and when the environment is the same the incidence of the disease is the same in all breeds and strains.' He found that the conditions under which the cattle are bred and reared constituted the most important contributory factor according to the opportunity supplied by the environment for the transmission of the bacilli. Regardless of breed as a separate factor, the proportion of cases of tuberculosis furnished by any breed is high or low according as the cattle are or are not in close association with other diseased animals. Calmette's experiments lend additional support to the same fact. He found that cattle which had been once infected nearly always recovered if they were carefully isolated, but if kept in prolonged contact with tuberculous animals they themselves became actively tuberculous.

So in man no race is exempt; in other words, there is a racial susceptibility to tuberculous infection, but there is not sufficient evidence at present to enable one to say that any *special* predisposition is handed on by tuberculous parents to their offspring.

We may summarise the matter by saying, firstly, that hereditary transmission of the bacillus is so rare that for practical purposes it may be declared negligible; secondly, that the incidence of tuberculosis depends on two main factors, namely, the dose received and the virulence of the strain inoculated; in other words, the degree of exposure to infection and the resistance which the inoculated subject is able to put forward, this, in turn, being dependent largely on his environment; thirdly, that there is not sufficient evidence, at present at all events, to afford support to the theory that there is such a thing as inherited predisposition to tuberculosis.

Before passing on to a more detailed description of some of the 300 cases of death from tuberculosis, the morbid anatomy of which forms the basis of these studies, it will be advantageous to say a few words on the extent to which the foregoing points are exemplified in the conditions prevailing in Hongkong.

Generally speaking, the prevalence of the disease is closely connected with social and economic conditions—overcrowding and slums, poverty, insanitation, and squalor. The ingestion of tuberculous milk, which is supposed to play a large part in the production of tuberculosis, especially intestinal tuberculosis, in children in England, has no influence here, for the Chinese children do not drink milk, nor does it arise here from the use of tuberculous meat.

The problems of tuberculosis in Hongkong are really social problems, and are, therefore, intimately connected with those of public health. The main causes of the prevalence of the scourge are the predisposing ones of overcrowding of the poor and the fact that the rooms inhabited by them are dark and the sunlight rarely enters them. They are still further darkened by gratings and shutters.

With the first of these there is little if anything to be done; the population is great and the space for their accommodation relatively small; not only is floor space inadequate, but window space is less than it should be, and the windows are often closed and made of opaque or coloured glass, so that the penetration of light is reduced to a minimum. This latter question of the darkening of the rooms can only be improved by education.

In an interesting paper on "Sanitary Progress in Hongkong," Dr. W. W. Pearse, the Medical Officer of Health, states with reference to the housing of the poorer Chinese that, the area being limited and the Chinese population large and constantly increasing, building sites have become very expensive so that the streets inhabited by this class of person are narrow, and the houses fronting on them high; in some cases the height is five times the width of the street.

'It is usual,' writes Dr. Pearse, 'to speak of the Chinese houses as being of one or more storeys, but as each storey was generally let separately, and as the occupiers of each storey used it as they would have used their single storey house in their native village in China, in effect these Chinese houses in Victoria were piled one on another, three, four and five high!

'Another factor has contributed curiously to produce the ill-designed Chinese house of Hongkong. The floors of these houses are supported by China fir poles. A pole of more than fifteen feet

long of sufficient strength for a floor joist is not readily procurable. This has limited the width of storeys to fifteen feet.

'In order to provide as much accommodation per floor as possible, *i.e.*, to make building pay, the area of a floor has been obtained by increasing its depth out of all proportion to its width.

'Hence a Chinese house in Hongkong has been a veritable tunnel fifteen feet wide and forty, fifty and even sixty feet deep.

'Excepting corner houses only, windows to light and ventilate these tunnels were possible only at the front and in front of these were verandahs.

'Windows at the rear of houses were not at first considered necessary, and many houses were built back to back, with no yard or ventilating shaft between them. On each floor the rear portion was cut off by a partition wall to form a kitchen. Such kitchens were small, generally under 150 square feet in area, very dark, and often with no means of ventilation other than the door communicating with the main portion of the floor. These kitchens were drained by vertical earthenware waste pipes which, in the case of back to back houses, were carried down through the building to discharge over a gully trap in the kitchen on the ground floor.'

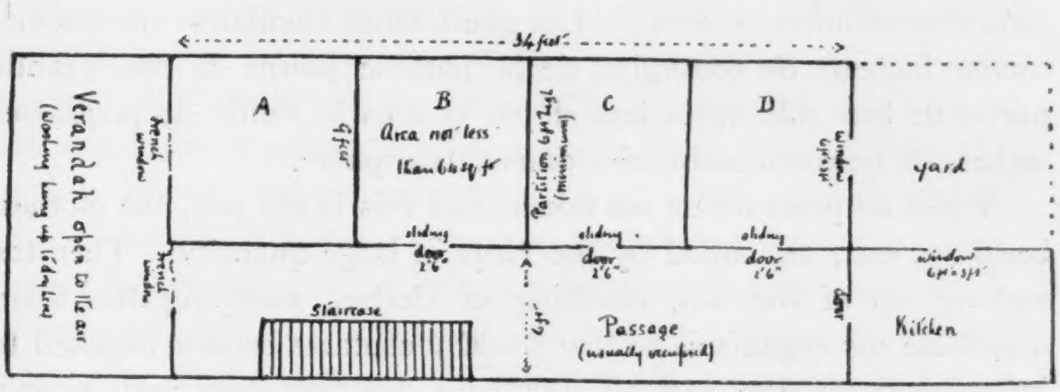
From time to time laws have been passed to improve the housing conditions by providing open spaces of a defined minimum area at the rear for ventilation. Later, all new houses were required to have larger back yards, and also scavenging lanes. Further, regular systematic cleansing of the Chinese houses was instituted (in 1903) and certain repairs effected. These measures were really directed towards the eradication or limitation of plague, and were aimed at affording protection from infestation with rats.

The method of cleansing the houses is carried out in the following manner four times a year: the furniture is turned out, the bed-boards and such like are dipped in 1 per cent. kerosene in water, in order to get rid of vermin; the floors also are sprayed with the same liquid. All rubbish and dirt generally are removed, and an inspector makes a careful examination to see if any floors need repair, if any gratings are missing, and so on.

The accompanying diagram, kindly drawn for me by Dr. W. J. Woodman, late Acting Medical Officer of Health for Hongkong, and now M.O.H., Kewleen, shows the arrangement and mode of

occupation of a typical 'floor' of a modern Chinese house in these districts.

The foregoing constitute the main predisposing causes, but the direct cause of the prevalence of tuberculosis in Hongkong is, *facile princeps*, the expectoration habit. Nearly all writers on tuberculosis in the tropics note this peculiar trait. In the houses of the poor a person will expectorate anywhere on the floor, or, if he is ill in bed, on the bed clothes. Owing to the unavoidable overcrowding in the poorer districts the children play about on the floor, putting everything into their mouths, breathing a vitiated



atmosphere and one often tubercle-laden. These are the reasons for the extensive prevalence of tuberculosis among the native population here and for the relatively high proportion of cases met with among children. A subsidiary but analogous cause is that manner of feeding their infants which many mothers, themselves tuberculous in some instances at least, indulge in, of first chewing the food and then placing it in the mouths of their babies.

Further, experiment has shown that there is considerable danger of transmission of tubercle bacilli from one person to another by means of eating utensils, if these are uncleaned. In China the eating together in common, the using of the same general dish, the insertion of individual chopsticks into the food supplied for the meal, the transference of food with the chopsticks of one person to the mouth or dish of another—all these afford a ready means of conveyance of the organism, but readily preventable when it once comes to be recognised.

These, however, are not so important as the one first named—the

expectoration habit—for intestinal tuberculosis, as shown in this series, is not the common mode of infection of children out here.

Dr. Chaussé compared the infection arising from dried sputum and that from droplets of sputum and saliva directly inhaled, and laid stress on the fact that it is exceptional for those living with tuberculous subjects to receive directly the cough of the latter, and the droplets are very soon diluted with a large quantity of air, and thus danger is lessened. Further, these droplets dry very quickly and their virulence is probably much diminished in ten days. Deposition occurs in a few hours at most, and, owing to the deposition and the drying, the droplets become reduced to the condition of infective dust. 'Les gouttelettes bacillaires elles-même, comme facteurs de contagion de la phthisie jouent la plus grande partie de leur rôle après leur dépôt et sous la forme de poussières sèches, de nouveau mobilisées dans l'atmosphère.'

When no precautions are taken, and this is the rule, the clothes, bedding, etc., are soiled by the virus in large quantity. Then the making up of the bed, brushing of clothes, sweeping the floor, distribute the organisms so that healthy contacts become exposed to infection every day and all day long, for this dust may remain suspended for several hours. Moreover, currents of air, movements on the part of the patients, continually put the dust in motion.

Then, when the colder months come on the Chinese take out their old clothing which has been stored away in some cupboard or dark corner and wear that over their other garments. When the house cleansing takes place these clothes are not disinfected, so that they are nearly, if not quite, as infectious as when they were laid aside at the termination of the previous cold weather.

Nuttall has estimated that a patient with open tuberculosis may expectorate four thousand million bacilli daily. In a dark, shut-in room the chances of infection for a child brought in contact with such a case are enormous. During the crawling age these chances are still greater. It will be seen on perusal of the age table appended that of the two hundred and twenty-five cases under ten years of age, one hundred and sixty-three, or 72·8 per cent., were three years old or less, and one hundred and eighty-five, or 82·2 per cent., under four years. Further, Dieudonné of Warzburg (1903) has proved that the nasal secretion and dirt on the hands of children

during the crawling age, say nine months to three and a half years, in a very large proportion showed the presence of tubercle bacilli. The opportunities for the repeated infection of a child of the crawling age in contact with a person suffering from open tuberculosis, or even living in a room previously occupied by such a person, are enormous. The danger of infection from tuberculous members of a family is not, according to the weight of evidence now available, due to the mere 'tendency to infection,' or even to the increased probability of infection *per se*, but is to be ascribed to the probable large size and frequency of the infecting doses. It has been shown experimentally that small repeated infections may be protective, but large ones overwhelm. Thus is explained the apparent antagonism of Calmette's and of Bryant's experiments. The former have already been mentioned with reference to single or repeated infection of cattle, either directly or by keeping them in contact with tuberculous animals. Bryant, after injecting guinea-pigs with a small number (eight) of bacilli daily for a time and then every three days for a period of four months, found lesions indicative of great resistance.

The conditions in Hongkong, as has been pointed out, are analogous to the experiments of Calmette. It is needless to labour this point further, but in conclusion mention may be made of Theobald Smith's statement in the *Journal of the American Medical Association*: 'The resistance of the tuberculous animal to super-infection is readily broken down by slightly increased dosage, and is successful only when very minute doses come into play.'

As already mentioned, the prevalence of tuberculosis is closely connected with social and economic conditions—overcrowding and slums, poverty, insanitation and squalor. With regard to over-crowding, little, if anything, can be done; the space available is limited, and the population is relatively large and is increasing. The question reduces itself, for practical purposes, to the finding of a remedy for the spitting habit in the first place. The use of food utensils, bowls, chopsticks, etc., in common probably plays a very subordinate part, as has been stated above. To exact, or rather to inflict fines for spitting in public would be useless for several reasons: firstly, the offenders cannot afford to pay fines; secondly, the native police are every bit as bad offenders in this respect as the rest; thirdly, I am convinced that it is the expectoration on the floors of the rooms in which the people live that is the chief source of the bacilli,

so that, even if expectorating in public out of doors were stopped—'a consummation devoutly to be wished' on other accounts than the risk of disseminating tubercle bacilli—there would be no deterrent to a man exercising the privilege in his own rooms, unless his wife objected, and this she would not do seeing that she also freely avails herself of a like privilege. We are, therefore, reduced to the slower but more certain method—Education, and the question naturally follows: How and by whom? European doctors would be of little, if any, use directly. They do not come into contact with the poor to any extent, and they would not be listened to even if they could succeed in making themselves understood. The Chinese doctors would have a better chance, and, therefore, much may be hoped from the locally qualified practitioner who comes more into contact with the people, both at the hospital during his years of training and also after he graduates and goes into practice.

Better still would it be to attempt to instruct the people in their houses, and this, I venure to suggest, could be accomplished in the following way:—The Y.M.C.A. and the Y.W.C.A., to which many of the better educated classes belong, have courses of lectures from time to time on various subjects. Like all the laity they are interested in medical questions, and there is no reason why popular (or, to use Huxley's preferable term, people's) lectures and demonstrations should not be given at these institutions, and such lectures on medical subjects never fail to draw. This would form a nucleus, and from among the members, the women more than the men, some would certainly be found to spread the glad tidings of the gospel of health, at first in their own homes among their servants, and later tactfully to promulgate the doctrines they had been taught. After a time a regular system of district visitors (in the medical sense) might be inaugurated; these would not only instruct the mothers in child welfare and the dangers of feeding their children in the way indicated earlier, but would instil into the adults, and, through them, the growing children health principles generally. The teachers of the Chinese attending British schools might also with advantage incorporate elementary hygienic principles as object lessons for their pupils. Then the question of the establishment of a tuberculosis dispensary would come up for consideration. The Chinese are very fond of their children, and the appalling mortality from tuberculosis must be ascribed to ignorance and not to perversity.

TABLE I.

Showing distribution of the 300 cases according to age and sex.

	Sex	6 months or under	6-12 months	1-1½ years	1½-2 years	2-3 years	3-4 years	4-5 years	5-10 years	Total up to 10 years	10-15 years	15-20 years	Total 10-20 years	20-30 years	30-40 years	40-50 years	50-60 years	Over 60 years	Total over 20 years
First hundred ...	M.	...	5	7	...	7	2	2	7	30	4	...	4	2	1	8	1	2	14
	F.	7	10	6	8	4	5	2	4	46	1	...	1	3	1	...	...	1	5
Second hundred ...	M.	3	7	5	2	5	6	1	3	32	...	...	...	6	3	8	3	...	20
	F.	3	11	4	3	8	2	2	8	41	2	1	3	1	1	1	1	...	4
Third hundred ...	M.	7	5	8	4	5	4	2	2	37	...	1	1	3	5	3	3	3	17
	F.	5	8	7	4	5	3	2	5	39	...	1	1	2	2	1	...	...	5
Whole three hundred ...	M.	10	17	20	6	17	12	5	12	99	4	1	5	11	9	19	7	5	51
	F.	15	29	17	15	17	10	6	17	126	3	2	5	6	4	2	1	1	14
Total, both sexes		25	46	37	21	34	22	11	29	225	7	3	10	17	13	21	8	6	65

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THE PREVALENCE AND CHARACTER OF TUBERCULOSIS IN HONGKONG

BY

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II. THE PORTALS OF ENTRY AND MODE OF SPREAD OF TUBERCULOSIS

The skin route as a portal of entry for tuberculosis which becomes widespread is negligible; the nose and mouth are the only ones worthy of serious consideration, and from the bacillary point of view a certain amount of exchange between the respiratory and alimentary tracts is possible; inhaled bacilli may be returned by ciliary action of the epithelial cells and swallowed, while the latter may in turn rise to the level of the larynx and be inhaled.

That bacilli when ingested can pass through the intestinal walls and affect the mesenteric glands without leaving any trace of their passage is a well-recognised fact, and they may also traverse or grow in and be transmitted from these glands to the lungs and elsewhere.

Experimental evidence goes to show conclusively that a very much larger dose of bacilli is needed to set up the disease by way of the alimentary tract than by the respiratory. In fact, there is considerable difficulty in infecting animals by feeding. As Cobbett states: 'The intestine is well guarded. It is otherwise with the lungs. While not open to the attack of common bacteria in anything like such numbers as is the intestine, it (*i.e.*, the lung) has not developed equal powers of defence, and tubercle bacilli when they enter the bronchi can effect an entrance (*i.e.*, penetration) and cause tuberculosis in numbers which would be powerless for harm if swallowed.' Thus, Gebhardt, working with diluted sputum, found that eight hundred bacilli sufficed to infect by inhalation, while ten to twenty millions failed when swallowed. Kossell, Weber and Heuse found that 1 milligramme would infect calves by inhalation, while one thousand times this dose given by feeding only caused

minimal lesions. More recently, Weber and Titze showed that it requires at least 10 mgrms. of bacilli to infect a calf by feeding, while 1/100 mgrm. may succeed when given by inhalation. Findel infected dogs by inhalation with doses down to 0·14 mgrms., while feeding with doses up to 63 mgrms. produced no effect whatever. Also sixty-two bacilli would constantly infect guinea-pigs by inhalation, even twenty sufficing in some cases, and in very young animals even five. He gave other guinea-pigs doses up to twenty thousand bacilli by feeding, but failed altogether to infect. Many species of animals, including calves, goats, dogs and guinea-pigs, are vastly more susceptible to infection by way of the air passages than by way of the alimentary canal.

The same investigator, Findel, again showed that five million tubercle bacilli when inhaled by a dog caused extensive tuberculosis of the lungs, while one thousand two hundred and twenty times that dose when given by the stomach produced no effect. As regards guinea-pigs, in some experiments as small a number as twenty bacilli were sufficient to cause pulmonary disease when inhaled, whereas the animals were able to withstand three hundred and eighty-two thousand times that dose when introduced into the alimentary canal.

Passing from these animal experiments to human cases, an interesting and instructive example was brought forward by Cautley in which one hundred and fifty-one children and two hundred and nine adults were unconsciously subjected to feeding experiments by consuming milk from tuberculous cows. Of these three hundred and sixty individuals 'only two of the children were affected, and they merely had a mild adenitis. . . They had taken the milk for a year and a year and a half respectively, and the milk was from cows with virulent disease of the udder. Such cases imply that to secure human infection by tuberculous milk the requirements are: youthful age, a badly infected milk, and the prolonged ingestion of such milk.'

Judging from this and the foregoing experimental work, we may say that the probabilities, when one finds what is apparently a primary lung infection, are that the condition has actually arisen by inhalation and not by way of the digestive tract. A more detailed consideration of the site of origin and the mode of spread in individual cases is given later with illustrations from this series.

The tonsils have been regarded by some as the portal of entry

for the bacilli, and they quote tuberculosis of these glands in support of their view. But as there is usually a focus in the lungs as well, it is rarely possible to say whether the primary site of infection was tonsil or lung, or whether both may not be secondary to another portal. As Austin says: 'Examples of apparently isolated tuberculosis of the tonsils should be regarded with reserve, as the presence of latent foci in the lungs can never be excluded.' Excised tonsils of forty-five children (aged $2\frac{1}{2}$ to 15 years) examined for tuberculosis by inoculation into guinea-pigs, by histological examination of sections, by cultures and by smears, all proved negative except one inoculation; we can say, therefore, that infection of the tonsils is uncommon alone. In fact, in most cases of tuberculosis of the tonsils lesions are found elsewhere, especially in the cervical glands, and it is rare to find tubercle bacilli in tonsils of children without clinical evidence of tuberculosis.

'By those who hold that pulmonary infection arises through the cervical glands,' says Dr. Whipham, 'various routes by which the tubercle bacilli may gain access to the lung have been suggested: first, that from the cervical glands they enter the lymph stream, and by means of the lymphatic vessels enter the venous system, and so are conveyed to the lungs; secondly, that their path is from the cervical to the supraclavicular glands, and thence to the apex of the lung; thirdly, that from the cervical they pass to the bronchial glands, and thence are conveyed to the blood-stream and the pulmonary tissues, though in this connection it must be remarked that no communicating channels between the cervical and bronchial glands have been shown to exist.'

The usual modes of entry and extension are, of course, the following:—

(1) Mechanically with air, food, secretions, and so on, as for example when inhaled bacilli lodge in some spot and produce a focal lesion or are returned by the action of the ciliary epithelium, as has been mentioned already; or a focus having formed, the material bearing organisms finds its way into a bronchus, the bacilli pass out and are swallowed or are drawn into another bronchus to set up the condition afresh there.

(2) By direct extension through the tissues with caseation of the parts first affected and involvement of the new tissues by contiguity.

(3) By way of the lymphatic channels which become invaded by

this contiguous extension. The bacilli thus pass to the next lymph-node, and so on by the lymphatic vessels till the thoracic duct conveys them to the left subclavian vein and the lymphatic mode of spread then becomes

(4) Dispersion or distribution by way of the blood-stream; thence they spread by the right side of the heart to the pulmonary arteries, and so to the lungs generally. Or, by the extension of a focus and erosion of the wall of a blood-vessel, they may pass by way of the pulmonary veins to the left side of the heart and thus to the whole systemic arterial distribution. Or yet again, by opening into a smaller artery will invade the area supplied by that vessel.

Cobbett, in his summing up, expresses his opinion in these words: 'While I have no doubt that tuberculosis is frequently of intestinal origin, especially in children, inhalation is the common mode of infection, not only in phthisis, but in other forms of tuberculosis, especially those in which the bronchial glands seem to be the parts first affected.'

In temperate climates isolated primary tuberculosis of the intestines, rarely seen in adults, is not uncommon in children (estimated at 25 per cent. according to some authorities); in tropical countries, judging from my experience in the West Indies (Jamaica) and the Far East (Hongkong), this route, or rather portal of primary entry, is not proportionately so common. Moreover, in temperate climates primary intestinal tuberculosis in children is usually ascribed, if not always traced, to the swallowing of the bacilli in quantities in infected milk. This is certainly not the case here.

It is probable that the intestinal infection is in the majority of cases secondary to lung tuberculosis from swallowing the sputum, even in children, and when definitely primary is due to direct ingestion of the bacilli from dried sputum in infected dwellings.

With this preliminary clearing of the ground we are in a position now to examine the extent to which these conditions as regards the portals of entry are borne out in my series.

Of the whole three hundred cases there were two hundred and nine in which the primary portal of entry appeared to be by the respiratory tract, *i.e.*, 69·66 per cent., and in seven others which are discussed later there was considerable evidence in support of the

same portal, bringing the total to two hundred and sixteen, or 72 per cent.

Only thirty-two have been definitely determined as being of alimentary origin, *i.e.*, 10·66 per cent.; five more, discussed below, were very likely alimentary; this would bring the total to 37, or 12·33 per cent.

In four other cases there was a possibility of almost simultaneous entrance by way of the respiratory and alimentary tracts. In the remaining cases the primary portal was uncertain. A few remarks are given subsequently on each of these.

The number of cases occurring in adults in this series is proportionately small, insufficient at present to form a useful basis for study in detail, and the main objects of this investigation have been the prevalence and character of the disease in children. Of the three hundred cases there were two hundred and twenty-five of ages up to ten years, and each consecutive hundred contained very similar proportions; thus there were seventy-six in the first, seventy-three in the second, and seventy-six in the third. As regards the sex and ages of those comprising the three hundred, the table (see p. 225) shows that one hundred and fifty-five were males and one hundred and forty-five females. It will be noted that after adult life the cases in males preponderate. Whereas in children up to the age of ten years the proportion of males to females is about as 4 : 5, after the age of twenty years the proportion is as 3·6 : 1. This does not mean that the males are more subject to tuberculosis in adult life than are females. When ill the Chinese exhibit strongly the homing instinct, and make every effort to return to their birthplace to die. The females can more easily do this; the males would if they could, but they in many cases have to remain at work until it is too late.

Of the two hundred and twenty-five children under ten years of age there were one hundred and twenty-six females (*i.e.*, 56 per cent.) and ninety-nine males (44 per cent.). This is not of much significance when we bear in mind that the female child in China is not considered of much account, and among the poorer classes from which these records have been made, the females are less well looked after. This is shown by the relative proportions of sexes for the early months of life.

Of the two hundred and twenty-five cases under ten years of age, then, one hundred and forty-eight, or 65·77 per cent., were found in whom the portal of entry was respiratory, and in five others (discussed later) there was a strong probability of a respiratory origin, in which case the percentage increases to 68.

Only thirty-one of these two hundred and twenty-five cases appeared to be definitely of alimentary origin, *i.e.*, 13·77 per cent., while among those of 'uncertain portal' were three others in whom the evidence for the alimentary route had considerable weight; if these be included the total percentage would be 15·11. Cases of isolated primary tuberculosis of the intestine are very rare here in my experience. In fact, only four were met with, namely, Nos. 7, 8, 81, and 112. The great majority, then, have a respiratory portal of entry, the proportion to alimentary being as great as between four and five to one.

In the following the primary portal was not determined with certainty. It will be of interest to give a brief note on each of them.

No. 15. Female, aged 22 months.

The extensive spread of miliary tubercles in the lungs, the meninges, liver, spleen, etc., indicate spread by the systemic blood-stream, possibly after the pulmonary circuit, but the only focus found was the caseating right broncho-pulmonary gland; how this became affected without some preceding lung focus I cannot say, but minute search failed to find any. Except for the gland all the tubercles appeared to be of the same age and recent.

No. 27. Female, aged 1 year.

There were two foci in the lower lobe of the right lung and miliary of the same lung with corresponding glandular affection, the gland at the left hilus probably by extension, the left lung not being affected. The intestine showed tuberculous ulceration and the mesenteric glands were in large caseous masses; the spleen was the only viscus with tubercles. If the primary portal were alimentary and the spread to the lungs via the thoracic duct, one would expect both lungs to be involved. In favour of the respiratory origin of the lung condition are the foci in the right lower lobe and the glandular involvement. The ages of the pulmonary and the intestinal conditions would appear to be about the same, and there is the possibility of the simultaneous entry by both routes.

No. 33. Female, aged 4 years.

A few miliary tubercles were scattered throughout the right lung and over the right visceral pleura; the superior tracheo-bronchial gland on the right was enlarged and contained creamy pus; the hilus glands were swollen. The left lung and glands showed no involvement. There were a few miliary tubercles over the spleen surface; miliary also at the base of the brain, especially about the interpeduncular space. Minute search failed to find any focus, unless the glandular abscess constituted it

No. 34. Male, aged 1 year.

In this case the broncho-pulmonary glands and some of the tracheo-bronchial were enlarged and caseous; minute search, however, failed to find any focus in either lung. The mesenteric glands were also, some of them, enlarged and caseating, but not adherent. The state of the mediastinal glands would warrant one in expecting to find a lung focus. In this connection may be quoted the results of experimental work by Calmette, Guérin, and Breton. They found that in guinea-pigs dying in two to four weeks after being fed on the bacilli the mesenteric glands (especially the superior deriving from the small intestine) were enlarged and inflamed, although no trace of any intestinal lesion could be determined. After 6-7 weeks these glands were caseous in greater or less degree and the lungs showed involvement by miliary tubercles with affection of the corresponding tracheo-bronchial glands. Hence in the present case the probability might seem to be primarily alimentary setting up mesenteric adenitis and mediastinal glandular affection secondary to this.

N. 35. Female, aged 2 years.

Infection extensive: broncho-pneumonic phthisis of the right lung with cavitation in the middle lobe; the left lung contained miliary tubercles all through, but no focus; mediastinal glands, as would be expected, were more affected on the right. The intestines showed numerous ulcers, one having perforated, and the mesenteric glands were large and caseous; the liver and spleen showed miliary tubercles, the latter more than the former, but the kidneys and brain showed none. The intestinal ulceration being so extensive, together with the condition of the mesenteric glands, favour the infection being primarily alimentary whence extension took place via the thoracic duct to the lungs, though the right lung was more affected than the left. On the other hand there had been time for cavitation to arise so that the intestine might have become involved through the swallowing of infected sputum. Here again the respiratory and intestinal conditions did not appear to differ greatly in age, and it is quite possible that the two-fold route was taken. One must always remember that to infer the relative ages of two tuberculous lesions from the stages present is a proceeding liable to fallacy.

No. 39. Male, aged 8 years.

This case showed widespread infection though the course of the extension is difficult to trace. The oldest sites would appear to be: (i) The left mastoid which was caseous and necrosed. As there was middle ear disease this may have been a condition apart from the tuberculosis; although caseous and necrotic, there was no actual proof of its being tuberculous in nature. (ii) Chain of large caseous cervical glands, more on the right than on the left. (iii) Thick caseous adherent peritoneum and mesentery as a vast cheesy sheet. (iv) Chain of large caseating mediastinal glands in relation to both lungs. (v) Focus in upper lobe of left lung. (vi) Mesenteric glands in large caseated masses. Other serous membranes—pleura and meninges—showed merely small miliary tubercles, in the latter limited to the base and not very numerous; the viscera—liver and spleen—showed none on section, merely a few on the surface; the kidneys none, and the intestines none, except miliary on the peritoneal surface. The disease would, therefore, not seem to have been a generalised blood-stream infection.

Was the primary portal of entry the intestine, affecting the mesenteric glands and the peritoneum without leaving any trace in the intestine itself, and thence spreading via the thoracic duct to the lungs? Or was the mastoid primary, thence

affecting the cervical glands (but the mastoid affected was the left while the glands were more marked on the right), and so by the blood-stream the lungs ? Or were the cervical glands affected via the tonsils (they showed no signs themselves), and thence the ear and lungs ? Or, lastly, was the primary route respiratory, thence to the mediastinal glands and to the blood-stream, and by the sputum to the alimentary canal ?

No. 50. Male, aged 3 years.

Focus in the left upper lobe and miliary throughout both lungs ; extensive intestinal affection—ulcers in both large and small intestines, mesenteric glands in caseous masses. Miliary tubercles in liver, spleen, and kidneys, but not in the meninges or brain. The alimentary appears a little older than the respiratory. The question is whether there was infection by double route, respiratory from the focus in the upper lobe of the left lung, and the intestine separately, or whether intestines first, thence by the mesenteric glands to the thoracic duct and lungs and then generalised ; but, if so, why should the meninges not show any involvement ? Or, again, the lung focus may have been the primary condition, the intestines have become affected from that by swallowing the sputum, and from the intestines the mesenteric glands, the lymphatic system, thoracic duct, superior vena cava, and again the lungs to produce the miliary condition there.

N. 52. Female, aged 4 years.

The distribution in this case was fairly general but showed certain peculiarities. There were a few minute tuberculous ulcers in an early stage in the small intestine with tubercles on the corresponding serous surfaces. The mesenteric glands, though not large nor adherent, were caseous. The peritoneum and omentum were thick and studded all over with tubercles varying from miliary to the size of large hempseed. As regards the viscera, the liver and still more the spleen showed miliary and grey tubercles, but on the surface only, none were seen on section. A remarkable thing, however, was that the ovaries were both enlarged, almost to the size of adult ovaries, and contained caseous masses, or rather consisted of a caseous mass in each case, the left a little larger than the right. The right lung contained two foci in the lowest lobe, the size of a pea, miliary tubercles throughout, and a more closely-packed mass of grey tubercles subapical in position ; the superior tracheo-bronchial and tracheal glands were enlarged and caseous. The left lung showed miliary tubercles throughout, with closely-packed milia on the somatic pleura ; none such were seen on the right. The pericardium also showed several miliary tubercles. There were a few scattered tubercles along and just above the right Sylvian fissure and some at the interpeduncular space. Which was primary is largely a matter of conjecture. For a single organ the ovary was the most extensively involved, each being converted practically into a cheesy, almost creamy, mass. The two lung foci had a fairly hard caseous consistence and were well defined. The alimentary tract tuberculosis and the serous membrane involvement, particularly the latter, were extensive, of the miliary type, though, as stated, a few of the glands were caseous.

No. 54. Female, aged 7 months.

Distribution widespread ; from appearances the respiratory and alimentary involvements seemed to be of about the same age. There was a focus at the lower edge of the right upper lobe, extending a little into the middle lobe ; miliary and grey tubercles were present elsewhere in the lungs, and the glands were caseous. Alimentary : ulcers in the small intestine, mesenteric glands adherent and caseous,

but not fused ; liver and spleen showed a few miliary tubercles. The right kidney had a small mass occupying the pyramid at the lower pole. The meninges at the base contained several miliary tubercles. A cervical gland on the right side was enlarged and beginning to break down in the interior. The question is whether the lung focus was the primary (the enlarged gland on the same side would support this) from whence extension occurred to the blood-stream to be generalised and by swallowing of the sputum the intestinal condition ; or, whether from the lung primarily to the intestine and mesenteric glands, and by the lymphatic system to the pulmonary circulation to set up the miliary tubercles there ; or, lastly, lungs and alimentary tracts together, then generalisation from the lungs to the systemic vessels and from the alimentary tract by the glands to generalisation in the lungs again.

No. 55. Male, aged 3 years.

The right lung showed tuberculous broncho-pneumonia of the middle and lower lobes ; the upper appeared to be quite unaffected. The middle contained at the lower part a cavity the size of a cobnut. The left lung consisted of three lobes and showed small ulcerated cavities throughout, the average the size of a pea, but rather larger in the middle lobe. Against the lung being primary is the fact that in spite of the extensive tuberculous condition of the organ the glands, though a little swollen and congested, showed no obvious tuberculous infection. On the other hand, the mesenteric glands were enlarged and three of them were caseous, almost chalky, though the intestines showed no change to the naked eye. The possibility is that the alimentary route was primary and thence affecting the lungs by the lymphatic system, the upper lobe escaping, and the hilus and other mediastinal glands not having become tuberculous before death supervened ; or that, since the pulmonary condition was broncho-pneumonic (rather than miliary by way of the pulmonary circulation), the disease had originated by the respiratory route and the alimentary tract had become involved by swallowing the sputum.

No. 58. Male, aged 14 months.

In spite of the age of this child the conditions were such that the general distribution of the disease makes it a matter of conjecture as to the primary portal of entry. There were signs of tuberculous broncho-pneumonia throughout both lungs, with ulceration in the left lower lobe. Generalisation by way of the blood-stream may have taken place from this, causing the deposition of tubercles in liver, spleen, kidneys, and brain. The intestinal ulceration and the masses of caseous mesenteric glands may have arisen from swallowed sputum, but the intestinal condition appeared to be equally advanced as the pulmonary and may have arisen independently. The pericardium also was studded with miliary to pin-head tubercles.

No. 59. Female, aged 4 years.

There was marked kyphosis from extensive involvement of the vertebrae. The spinal site was probably the oldest. From the number of ulcers in the intestines, the large and small both being involved, and the mesenteric glands being in large caseous masses, the alimentary tract would appear to have been attacked prior to the lungs. The latter showed miliary tubercles throughout, but there was also a fair-sized focus (cobnut) just below the apex of the right lower lobe in an early stage of caseation.

No. 65. Female, aged 8 months.

The peculiar limitation of the disease in the lungs to the middle lobe of the right, which contained a distinct focus the size of a pea and small miliary and grey tubercles throughout that lobe, would be in favour of a primary (or at least independent) lung involvement, the alimentary tract being affected secondarily from swallowing the sputum. The mesenteric glands, however, were in large caseating masses and appeared to be of older standing than the pulmonary condition.

No. 66. Female, aged 20 months.

In some respects similar to the last. In this case the lung affection was limited to the right upper lobe in which there was a subapical focus, and in addition generalisation of small tubercles throughout that lobe. The disease was much more advanced in the alimentary tract—intestinal ulceration and large caseous masses of mesenteric glands—and this would point to an alimentary portal of entry. It is not improbable that the lung infection, though later, was independent of the intestinal. The condition of the brain (cerebellar mass) and meninges (miliary to hempseed on vertex and base) point to dissemination by the blood-stream, but no other viscera showed involvement, to the naked eye at least.

No. 68. Male, aged 3 years.

This case is remarkable in that, except for a hilus gland and a paratracheal gland on the right side as large as a cobnut and filbert respectively and caseous, no focus was found after careful search. There were sparse miliary tubercles throughout both lungs; in the meninges they were numerous, especially at the base, the interpeduncular space, the ependyma, along the Sylvian fissures, and a few on the vertex. The spleen showed also a few milia on the surface. There was no evidence of tuberculous affection of the intestines.

No. 70. Female, aged 7 years.

In this child there was a mass of caseating glands on both sides, involving the inferior and superior tracheo-bronchial and the paratracheal, more on the right than the left; the broncho-pulmonary were not apparently affected. No focus was found in the lungs. The tonsils were not affected, nor the cervical glands, and the spine was examined without success. The alimentary tract was free. In the kidneys, however, there were in the left miliary and grey tubercles, not numerous; in the right more, and arranged almost focally as a group at the base of a pyramid towards the lower pole.

No. 92. Male, aged 10 years.

The primary portal in this case was probably alimentary. There were several ulcers, more in the large than small intestine, however, and a thickened tuberculous mass like a collar at the ileo-caecal valve. Mesenteric glands were enlarged, in masses, and caseating. The lungs showed tubercles varying in size from pin-point to small pea throughout, but the mediastinal glands did not show any tubercles visible to the naked eye, and only one was a little congested and swollen. Neither brain, liver, nor spleen showed any signs, but the kidneys were severely diseased. The right had the pyramidal areas hollowed and caseous; they had run together and were lined by thick tuberculous matter. The left was in a similar condition but to a less degree; calyces opening into each other with a lining of tuberculous pus. The tuberculosis was, therefore, widespread, but if by way of the blood-stream it is peculiar that the kidneys should have been

extensively affected while the brain, liver, and spleen escaped. The lung condition appeared to be more recent than the intestinal and may have arisen by way of the pulmonary circulation as previously pointed out.

No. 95. Female, aged 8 years.

In this case one of the inferior tracheo-bronchial glands was caseous and one of the superior in an earlier stage, both on the right side, but minute search failed to find any tubercles in the lungs. The intestines were not affected, and no focus was detected anywhere. The meninges showed miliary tubercles in fair numbers at the base, fewer along the Sylvian fissures, and only an occasional one at the convexity. No tonsillar or retro-pharyngeal affection was detected. If the meningeal condition arose by inhalation, via the ethmoidal canals (as meningococcus may pass), then we have no explanation of the mediastinal gland affection. Anyway these do not appear to be accounted for, though the spread may have been from them by the blood to the meninges.

No. 96. Female, aged 9 years.

In this case both the respiratory and alimentary tracts showed such extensive involvement that the only doubt is whether the lungs, which were in a state of tuberculous broncho-pneumonia throughout, with cavitation in the right upper lobe and considerable ulceration in the middle lobe, were the primary seat and the intestine was involved later through swallowing the sputum, or whether the alimentary tract formed the primary portal of entry. The small intestine contained tuberculous ulcers ; the mesenteric glands were in large caseated masses and adherent, and the peritoneum was studded with tubercles. Of course, there may have been infection by both routes nearly simultaneously.

No. 100. Male, aged 5 years.

In this child there was a cavity in the right upper lobe the size of a medlar, with grey tubercles surrounding it and smaller ones at a greater distance. No other part of the right lung was affected and the left showed nothing. There were pleural adhesions at the apex and direct communication with a tuberculous ulcer the size of a crown-piece above the right clavicle. Whether a supraclavicular gland had become infected from the lung direct and had then opened on the surface, or whether there was a primary affection of the skin which ulcerated and extended to the lung is doubtful. There was a tuberculous skin affection with early ulceration on the right cheek also. No other viscera showed any involvement, and no cervical glands were found enlarged. This may be an example of the mode of spread already mentioned.

No. 104. Male, aged 16 months.

In this the disease was widespread and the primary portal and mode of extension doubtful. The left lung showed two foci, one subapical in the lower lobe, the other nearer the lower edge, and each was surrounded by a zone of small caseating tubercles. The right upper and lower lobes contained miliary tubercles ; the glands, hilus, and tracheo-bronchial were caseous and enlarged. In the alimentary tract there was nothing, but one or two mesenteric glands contained small foci. Milia were present in the liver, more and larger in the spleen. The meninges had masses of miliary tubercles at the base, and along the Sylvian fissures and in the interpeduncular space ; a few on the vertex and internal surfaces of the cerebral hemispheres. The spine showed a large abscess the size of a Tangerine orange, involving the 11th and 12th dorsal and the 1st lumbar vertebrae. Sug-

gested method of spread : Lung (left), then by inhalation the right, by the blood-stream to the liver, spleen, spine (injury possibly determining this site), and also by the sputum to the intestine and mesenteric glands ; or, from the left lung foci by the sputum to the intestines and mesenteric glands, thence by the lymphatic system to the heart and pulmonary circulation, causing the miliary tuberculosis of the right lung, and also by way of the blood-stream from the lung to the liver, spleen, and meninges. But the spine focus must have been of considerable standing, for there was marked caries and an abscess formed containing caseous matter.

No. 116. Female, aged 10 months.

The right lung showed two distinct foci in the upper lobe : the larger subapical the size of a cherry and caseous, the smaller the size of a pea, near the interlobar fissure ; the rest of the lung contained miliary tubercles. The left lung showed miliary to pin-head tubercles, sparse in the upper lobe, more in the lower. The mediastinal glands were enlarged, with caseating foci. The mesenteric glands (the upper set) were in a similar condition. The question is whether both the respiratory and alimentary tracts were involved simultaneously, or whether the lung focus was primary, the alimentary secondary, passing to the glands without leaving signs in the intestine itself. Thence by the lymphatic to the pulmonary circulation to set up the miliary tuberculosis there, and from the lungs via the blood-stream to the meninges, liver, and spleen. But, if so generalised, one would hardly expect the kidneys to escape altogether.

No. 118. Female, aged 3 years.

In this case the disease was exceedingly widespread and the portal of entry is a matter of conjecture. There were tuberculous ulcers of the right cheek, jaw, and neck ; the right parotid, the submaxillary and cervical glands on both sides, were caseous. There was tuberculous broncho-pneumonia throughout both lungs, the pleura showed many tubercles at the upper part of the somatic layer and all over the visceral ; the pericardium was also affected. The peritoneum was studded with tubercles, miliary to pea, and the intestines contained a few tuberculous ulcers, both in the large and the small ; the mesenteric glands, both upper and lower series, were enlarged, adherent, and caseated. The liver showed a few miliary, the spleen more and somewhat larger. In the right kidney was a small mass of aggregated tubercles at the lower pole, while in a corresponding situation in the left was a definite caseous focus the size of a cherry. There were aggregated miliary tubercles on the basal meninges, a few also on the vertical.

No. 137. Male, aged 10 months.

Disease was widespread and severe in this child, especially when one considers the age. The lungs showed a cavity in the lower lobe, a caseous focus in the middle, and miliary tubercles throughout the remainder of the right ; in the left there were two caseous foci the size of a pea in the upper lobe, a caseous mass as large as a walnut in the lower, and grey tubercles through the rest of the lung. All groups of the mediastinal glands were involved. The mesenteric were enlarged, caseous, and matted, but appeared to be more recent than the thoracic. There were two tuberculous ulcers in an early stage in the small intestine. The femoral glands on each side were the size of a small walnut and caseous (the origin of these could not be discovered). The cervical glands on each side were caseous, especially on the right. The right kidney contained a small aggregation of tubercles at the lower pole ; the liver a few miliary tubercles, the spleen more and larger. The meninges were not affected. As the respiratory and alimentary tracts were both

involved, and also some glands unconnected with either, it is difficult to say which was the primary portal, but the lungs would seem to be most involved and of oldest standing.

No. 141. Male, aged 10 years.

The oldest site in this case was to the right of the sixth cervical vertebra. The bone was carious, and there was a sac with pus discharging from it along the spine into the right pleural cavity (it may possibly have started as a retropharyngeal abscess). The right lung showed miliary tubercles throughout, not very numerous, but more in the upper lobe than in the other two. The left lung had none. There was a caseous gland at the right hilus. Tuberculous sinuses were present in both femora and in the left tibia.

No. 145. Female, aged 2½ years.

Judging from the appearance, degree of caseation, etc., the primary portal may have been alimentary, but the disease was very widespread, the brain showing several foci. There were tuberculous ulcers in both large and small intestines, and the mesenteric glands were in adherent, caseous masses. The cervical gland infection was of fairly long standing also, those on the right containing creamy pus, those on the left being in a caseated stage. Both lungs showed grey tubercles, and the mediastinal glands were in caseous masses at the hilus and along both sides of the trachea. The brain showed: three distinct foci in the left lobe of the cerebellum, another in the right hippocampus, another in the left superior frontal, all these about the size of a pea or a little larger, and in the right supramarginal gyrus one as large as a cherry—an extensive series of brain foci.

No. 149. Female, aged 3 years.

It is possible that the alimentary portal was the primary as this tract showed the greatest involvement (not a very safe indication, it is true). There were numerous ulcers in both large and small intestines, the mesenteric glands, both upper and lower series, were enlarged, adherent, and caseous. The lungs contained closely aggregated miliary and grey tubercles throughout, but no focus, although the mediastinal glands on both sides were caseous and the paratracheal on the right contained creamy pus. The brain was considerably involved: there were a few miliary tubercles in the basal meninges, many along each Sylvian fissure, and a few on the opposed surfaces of the cerebral hemispheres; in the cerebellum at the fore part of the left hemisphere on the upper surface there was a 'solitary' tubercle, as large as a cherry, and towards the posterior another focus the size of a haricot; on the under surface of the right hemisphere was one the size of a filbert situated anteriorly, and at the posterior extremity another the size of a pea. As regards the course, it does not appear likely that the large tubercles in the cerebellum would be of the same standing as the miliary in the meninges. The intestinal appeared to be the oldest, the lungs probably secondary to this via the pulmonary circulation, for the distribution was equal over both lungs which were granular everywhere from miliary and grey tubercles. General blood infection was supported by the presence of a few tubercles in the liver, spleen, kidney, and meninges, and probably an earlier blood infection set up the various brain tubercles.

No. 157. Male, aged 5 years.

Lungs were granular in appearance from the presence of numerous grey tubercles. A gland at the right hilus was swollen and congested, but showed no signs of tuberculosis in it. Intestines nil. One mesenteric gland, the size of a pea,

contained small grey points. Both kidneys showed miliary tubercles, the left a little more than the right. There were milia also in the liver, spleen, and meninges. No focus could be found. The universality and evenness of the pulmonary distribution point to a haemic infection of the lungs rather than a respiratory.

No. 159. Female, aged 8 years.

The condition in the lungs and in the abdomen appeared to be of about equal development. There were two foci in the left lung, one in the upper lobe the size of a small cherry, caseous with a fibrous border, another in the lower lobe slightly larger. The right upper lobe showed tuberculous broncho-pneumonia, the middle and lower many grey tubercles. The mediastinal glands on both sides were enlarged and caseous. The alimentary tract showed several tuberculous ulcers in the small intestine, and the corresponding mesenteric glands were in caseous adherent masses. There is apparently equal evidence for respiratory and alimentary portals, and the stage in each is about the same. Possibly the double route was taken nearly simultaneously.

No. 160. Male, aged 3 years.

Miliary tuberculosis of the lungs and meninges, a few also in the spleen. Two paratracheal glands were swollen and contained two small caseous foci, and one at the hilus was enlarged and caseous. No focus was found anywhere.

No. 164. Female, aged 6 years.

The difficulty in this case is to decide, in view of the widespread condition, which was the primary portal of entry. There were old-standing ulcers beneath each ear, with caseated and breaking-down cervical glands. The right lung showed several foci, certainly not of recent production, one the size of a pea, deep in the upper lobe, another similar at the base of the lowest; a small cavity in the middle, and, at the upper part of the lowest, a large focus the size of a cherry, caseous, with surrounding tubercles and early ulceration. In addition to these there were milia throughout the lungs. There were tuberculous ulcers in the intestines; the mesenteric glands were enlarged, caseous, adherent. The meninges showed numerous tubercles at the base and along the Sylvian fissures, more again below the cerebellum. The vertex and inter-hemispherical aspects showed tubercles in fair numbers. In spite of the lung condition the mediastinal glands, though containing tuberculous foci, were not nearly as much affected as the mesenteric. The respiratory and alimentary appeared to be of nearly equal age, as regards the foci; the miliary state of the lungs may be a secondary result of the intestinal. Doubtful whether: (i) Focal pulmonary, then intestinal, mesenteric, generalisation in lungs and thence the brain; or (ii) Primarily skin, then glands, blood-stream and generalisation; or (iii) Skin, lungs, intestines (the last two independently and simultaneously, as regards the focal state), and subsequent generalisation.

No. 178. Female, aged 10 years.

Miliary tuberculosis of both lungs, fairly numerous and evenly distributed, but rather more in the right lung. A gland at the right hilus and one paratracheal caseous. Nothing in the alimentary tract. A few miliary in the meninges, more at the base, but some also at the vertex. No focus detected anywhere.

No. 181. Female, aged 4 years.

Meninges showed general involvement, more aggregated at the base, in the interpeduncular space, along the Sylvian fissures, and below the cerebellum ; few on the convexity. The lungs showed widespread miliary tubercles, more numerous in the right than the left. Mediastinal glands on the right were enlarged and caseous, but no focus was found.

No. 203. Male, aged 5 years.

Miliary tubercles scattered in moderate profusion and evenly through both lungs, but the source of these was not detected. The alimentary tract did not show any involvement, but one mesenteric gland was the size of a pea, and on section contained a minute caseous point. There was extensive tuberculous meningitis ; at the base they were closely aggregated and pus was forming ; there were also many along the Sylvian fissures and only a little less on the convexity. The ventricles contained more than the normal amount of fluid. No focus was found.

No. 206. Male, aged 16 months.

Grey tubercles in the upper lobe of each lung and less in the right middle lobe. The spleen showed a considerable number of miliary tubercles. The meninges were extensively affected ; there was pus at the base with very numerous tubercles, also along the Sylvian fissures, in the velum interpositum and below the cerebellum. No focus was found, the other viscera yielding no evidence.

No. 210. Male, aged 5 years.

Here again no focus was found. The right lung contained miliary tubercles in the middle and lower lobes, and a gland at the hilus was caseated. The upper lobe of the left lung also contained miliary tubercles ; there was no affection of the glands on the left ; a few miliary were seen also in the spleen, while the meninges were extensively involved : tubercles were numerous at the base and along the Sylvian fissures, and there were one or two on the convexity and on the opposed surfaces of the cerebral hemispheres.

No. 211. Female, aged 5 years.

Apparently a haematogenous infection, but the primary focus was not found. The lesions were miliary tuberculosis of both lungs, the spleen, and the basal meninges.

No. 215. Female, aged 13 months.

The disease in this child was extensive and the decision as to the primary portal of entry a matter of opinion. There was a caseous focus as large as a filbert in the right lung, and grey tubercles throughout both lungs, while all groups of the mediastinal glands were enlarged and caseous. The cervical glands were a little affected. The mesenteric were in adherent caseous groups of about the same degree of involvement as the mediastinal ; there were miliary tubercles of the liver and spleen, and a terminal meningitis. The mesentery and peritoneum generally were studded with tubercles. From the state of the glands in the thorax and abdomen there is no evidence for priority. The lung condition with a caseous focus of such a size must be of considerable standing, whereas the intestine itself showed one small ulcer only. On the other hand, the extensive affection of the peritoneum indicated that the abdominal condition was not very recent. On the whole, unless we regard the respiratory and alimentary as about coequal

contained small grey points. Both kidneys showed miliary tubercles, the left a little more than the right. There were milia also in the liver, spleen, and meninges. No focus could be found. The universality and evenness of the pulmonary distribution point to a haemic infection of the lungs rather than a respiratory.

No. 159. Female, aged 8 years.

The condition in the lungs and in the abdomen appeared to be of about equal development. There were two foci in the left lung, one in the upper lobe the size of a small cherry, caseous with a fibrous border, another in the lower lobe slightly larger. The right upper lobe showed tuberculous broncho-pneumonia, the middle and lower many grey tubercles. The mediastinal glands on both sides were enlarged and caseous. The alimentary tract showed several tuberculous ulcers in the small intestine, and the corresponding mesenteric glands were in caseous adherent masses. There is apparently equal evidence for respiratory and alimentary portals, and the stage in each is about the same. Possibly the double route was taken nearly simultaneously.

No. 160. Male, aged 3 years.

Miliary tuberculosis of the lungs and meninges, a few also in the spleen. Two paratracheal glands were swollen and contained two small caseous foci, and one at the hilus was enlarged and caseous. No focus was found anywhere.

No. 164. Female, aged 6 years.

The difficulty in this case is to decide, in view of the widespread condition, which was the primary portal of entry. There were old-standing ulcers beneath each ear, with caseated and breaking-down cervical glands. The right lung showed several foci, certainly not of recent production, one the size of a pea, deep in the upper lobe, another similar at the base of the lowest; a small cavity in the middle, and, at the upper part of the lowest, a large focus the size of a cherry, caseous, with surrounding tubercles and early ulceration. In addition to these there were milia throughout the lungs. There were tuberculous ulcers in the intestines; the mesenteric glands were enlarged, caseous, adherent. The meninges showed numerous tubercles at the base and along the Sylvian fissures, more again below the cerebellum. The vertex and inter-hemispherical aspects showed tubercles in fair numbers. In spite of the lung condition the mediastinal glands, though containing tuberculous foci, were not nearly as much affected as the mesenteric. The respiratory and alimentary appeared to be of nearly equal age, as regards the foci; the miliary state of the lungs may be a secondary result of the intestinal. Doubtful whether: (i) Focal pulmonary, then intestinal, mesenteric, generalisation in lungs and thence the brain; or (ii) Primarily skin, then glands, blood-stream and generalisation; or (iii) Skin, lungs, intestines (the last two independently and simultaneously, as regards the focal state), and subsequent generalisation.

No. 178. Female, aged 10 years.

Miliary tuberculosis of both lungs, fairly numerous and evenly distributed, but rather more in the right lung. A gland at the right hilus and one paratracheal caseous. Nothing in the alimentary tract. A few miliary in the meninges, more at the base, but some also at the vertex. No focus detected anywhere.

No. 181. Female, aged 4 years.

Meninges showed general involvement, more aggregated at the base, in the interpeduncular space, along the Sylvian fissures, and below the cerebellum; few on the convexity. The lungs showed widespread miliary tubercles, more numerous in the right than the left. Mediastinal glands on the right were enlarged and caseous, but no focus was found.

No. 203. Male, aged 5 years.

Miliary tubercles scattered in moderate profusion and evenly through both lungs, but the source of these was not detected. The alimentary tract did not show any involvement, but one mesenteric gland was the size of a pea, and on section contained a minute caseous point. There was extensive tuberculous meningitis; at the base they were closely aggregated and pus was forming; there were also many along the Sylvian fissures and only a little less on the convexity. The ventricles contained more than the normal amount of fluid. No focus was found.

No. 206. Male, aged 16 months.

Grey tubercles in the upper lobe of each lung and less in the right middle lobe. The spleen showed a considerable number of miliary tubercles. The meninges were extensively affected; there was pus at the base with very numerous tubercles, also along the Sylvian fissures, in the velum interpositum and below the cerebellum. No focus was found, the other viscera yielding no evidence.

No. 210. Male, aged 5 years.

Here again no focus was found. The right lung contained miliary tubercles in the middle and lower lobes, and a gland at the hilus was caseated. The upper lobe of the left lung also contained miliary tubercles; there was no affection of the glands on the left; a few miliary were seen also in the spleen, while the meninges were extensively involved: tubercles were numerous at the base and along the Sylvian fissures, and there were one or two on the convexity and on the opposed surfaces of the cerebral hemispheres.

No. 211. Female, aged 5 years.

Apparently a haematogenous infection, but the primary focus was not found. The lesions were miliary tuberculosis of both lungs, the spleen, and the basal meninges.

No. 215. Female, aged 13 months.

The disease in this child was extensive and the decision as to the primary portal of entry a matter of opinion. There was a caseous focus as large as a filbert in the right lung, and grey tubercles throughout both lungs, while all groups of the mediastinal glands were enlarged and caseous. The cervical glands were a little affected. The mesenteric were in adherent caseous groups of about the same degree of involvement as the mediastinal; there were miliary tubercles of the liver and spleen, and a terminal meningitis. The mesentery and peritoneum generally were studded with tubercles. From the state of the glands in the thorax and abdomen there is no evidence for priority. The lung condition with a caseous focus of such a size must be of considerable standing, whereas the intestine itself showed one small ulcer only. On the other hand, the extensive affection of the peritoneum indicated that the abdominal condition was not very recent. On the whole, unless we regard the respiratory and alimentary as about coequal

in age, the most satisfactory explanation would be, the lung focus primarily, alimentary secondarily, thence the peritoneum and mesenteric glands, and via the thoracic duct to the pulmonary circulation and so setting up generalisation there, and via the blood-stream (systemic) to liver, spleen, and meninges.

No. 222. Female, aged 18 months.

Though the mediastinal glands on the right side were enlarged and caseous, no true focus was present in the lungs. The middle and lower lobes showed grey tubercles of the minute bronchioles, while the right upper and both lobes of the left contained miliary tubercles by the blood-stream. Some of the mesenteric glands were the size of a small pea and had caseous points. The liver, spleen, and kidney contained tubercles varying from small miliary to hempseed, and the base of the meninges showed them also. On the whole the sequence was probably : Respiratory first, causing the broncho-pneumonia of the lower lobes of the right lung, then alimentary to the mesenteric glands, without leaving signs in the intestine itself ; thence by the lymphatics to the pulmonary circulation and so miliary generalisation in the lungs, and from there to the liver, spleen, kidney, and meninges.

No. 223. Female, aged 4 years.

Extensive tuberculous meningitis, but no focus detected anywhere.

No. 227. Female, aged 3 years.

Lungs extensively affected with miliary and small grey tubercles, the right rather more than the left. There were numerous tubercles in the meninges, and a few in the liver and spleen, but no definite focus or indication of the primary portal of entry.

No. 230. Male, aged 3 years.

Tuberculous meningitis most severe, but the origin of this could not be traced. No focus was found, but there was miliary tuberculosis of the lungs, liver and spleen.

No. 239. Female, aged 3 years.

In this case the alimentary, as evidenced by the state of the mesenteric glands, would appear to be the oldest ; on the other hand the caseous focus in the left lung would be of older standing than the miliary and grey tubercles scattered generally throughout the lung. Also the mediastinal gland corresponding to the lung focus was completely caseous, like the mesenteric glands. The cerebellar focus was not very recent, less so than the miliary in the lungs and meninges. There are three possibilities : (i) Primary lung focus, alimentary secondarily, then generalisation in the lungs and from there to the meninges (if so, whence would the 'solitary' tubercle in the cerebellum arise, unless by separate earlier metastasis from the lung focus ?). (ii) Primary intestinal, secondary focus in lung and spread from there by inhalation to other parts of the lung, and by blood-stream to the cerebellum and meninges (but the cerebellar is a caseous node, while the meningeal affection is miliary and apparently recent). (iii) Lung and alimentary routes about the same time (judging from the glandular infection those in the thorax and those in the abdomen appear to be about the same stage), then from the lung to the cerebellum (focus), and from the mesenteric glands to the right side of the heart for the production of the miliary and grey tubercles in the lungs.

No. 275. Female, aged 6 years.

The lesions found were a general miliary infection of the right lung, and a few milia in the upper lobe of the left; an enlarged and caseated paratracheal gland on the right; sparse miliary tubercles in the spleen, and fairly thickly-studded miliary infection of the meninges, more aggregated at the base. No focus was discoverable, unless the mediastinal gland be regarded as such, but no evidence of the communication of this with a pulmonary vessel could be made out to account for the distribution in the lung, and there was certainly no focus in the lung to which this gland could be attributed.

No. 283. Male, aged 4 years.

The lungs in this case presented miliary tubercles, rather more in the right than the left, but not very numerous in either; the hilus on the right showed a large caseous gland, and one paratracheal on each side was caseated, that on the right being the larger. No focus was found in the lungs to account for these glands. There were a few miliary tubercles in the liver, more in the spleen. The meninges were severely affected, at the base and over the right hemisphere. In the latter, just below the cortex of the angular gyrus, was a mass of tubercles focally arranged, aggregating to the size of a large pea or small marble. The cerebral condition had probably arisen by vascular spread from the mediastinal gland, but the source of the latter was not found.

No. 291. Female, aged 4 years.

The only focus detected in this case was a caseous mass occupying nearly an entire pyramid at the lower part of the left kidney. There was miliary tuberculosis of the lungs, but no focus. No infection of the intestines; only one mesenteric gland showed anything and this was not so large as a haricot, but had a small caseous point. There were also a few milia in the liver. The kidney lesion was to all appearances the oldest, but whence this arose could not be discovered.

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MULTIPLE ANEURYSMS IN A CHILD

BY

R. H. KENNAN, M.D.

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The patient is a well-grown, intelligent, active but anaemic boy of four years old; the son of observant, healthy white parents, American Missionaries on leave from Sierra Leone. The boy had had about six attacks of fever, each of short duration, in Freetown, and the latest of these occurred in October last. His tongue was clean and moist and without tremor; his gums healthy; his pulse regular and of good quality, with frequency of ninety-two beats per minute while he was in the erect posture. His heart was free from murmur and normal, and no enlargement of his liver or spleen or lymph glands could be detected. There was no sign of rickets and his urine (acid, 1,022) was free from albumen and sugar. His parents suggested that there was oedema of his eyelids, but at the time of examination (about 4 p.m.) I could not satisfy myself that oedema was present.

The upper end of the left hypothenar eminence was slightly enlarged, and prominent, and was the site of a pulsating tumour which could be 'emptied' by pressure over it, and which then filled again 'per saltum.' Pressure over the ulnar artery greatly diminished, but did not entirely obliterate pulsation in the tumour. The surface tissues over the tumour were unaltered in colour and texture. Just above this tumour, and separated from it by a narrow surface depression, was a second one of similar character.

There was no history of injury antecedent to the first hypothenar tumour, which was first noticed in March, 1920; the second swelling appeared in October, 1920: the parents state that it came quickly two days after a fall, which, however, did not cause bruising or damage to the skin. Subsequently a small pulsating little vessel, slightly bluish in colour was noticed about the middle of the right

side of his neck, and some time after this, while his mother was examining his neck, she found another larger pulsating, uniformly oval swelling a little lower down, occupying the greater portion of the base of the anterior triangle of his neck above the clavicle. The skin over it was freely moveable, as was also the tumour from side to side, but it was not capable of displacement vertically. Vigorous pulsations were easily observable by sight and touch in the little vessel; the pulsations could be stopped by slight pressure below the point where it lay immediately beneath the skin. The larger, lower tumour could not be emptied by pressure over it, but the pulsations, synchronizing with the ventricular systole, appeared to be distensile in character, and with a stethoscope a loud bruit was audible over it. The radial pulses were of equal volume, and no difference in colour or temperature of the hands could be detected. It could not be decided whether the wrist and hypothenar tumours were separated by normal vessel or whether the surface depression was due merely to compression by fascial bands. None of the tumours caused any pain, and only when the larger neck tumour was firmly pressed in an effort to empty it did the patient show any sign of distress.

Examination of the blood showed *Plasmodium falciparum* infection and also eosinophilia (about 12 per cent.). Several very careful and prolonged examinations of the faeces yielded negative results.

There appears to be no doubt that the two distal tumours are arterial aneurysms, and that both the abnormal conditions in his neck are of the same kind. The alternatives of 'venous pulsation,' and 'enlarged lymph gland with transmitted pulsation' were borne in mind at the time of the examination.

Macfie and Ingram (1920) have described 'Three cases of Cardiac Aneurysms in Native Boys of the Gold Coast,' and discuss the question of aetiology, and the suggestion is made that malaria may have been a factor in causation of the aneurysms.

Aneurysms of the large arteries have been frequently reported as having occurred in young children, even as early as in foetal life, but in the present case not only was the child four years old, but the aneurysms were several and their etiology obscure. Stress has been laid by many on the effect of septic emboli in weakening the artery wall by inflammation spreading from the infective clot in causing

aneurysms in children suffering from septic endocarditis, but no such cause was operative in this case. Syphilis is also commonly considered a cause, but though no Wasserman blood test was made on this boy, it is extremely improbable that syphilis was present. Though there was a history of a fall antecedent to the appearance of one of the tumours in this case the relationship of the two things as cause and effect was not definite, while in the cases of the neck tumours any competent injury must have been obvious at the time it occurred. As causes, it appears that septic emboli, syphilis and injury were not present in this case.

At one time, the presence of four arterial dilatations in a child of four years old would have been held to justify the non-illuminating diagnosis of 'aneurysmal diathesis.'

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LAPPETED *ANOPLOCEPHALA* IN HORSES

BY

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AND

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(*Received for publication 22 July, 1921*)

PLATE XVII.

I. *ANOPLOCEPHALA RHODESIENSIS*, nom. nov.

About two hundred and fifty specimens of this parasite were collected by one of us in 1912, from eight zebra (*Equus burchelli*) in North Eastern Rhodesia.

TECHNIQUE. Most anatomical details were easily elucidated by the following procedure:—

The worms were stained, *en masse*, for several days in dilute acetic-acid-alum carmine, then washed and taken through the alcohols into clove oil. As soon as the worm was clear, it was placed under a binocular microscope and segments were detached, one at a time, by means of a surgical needle or cataract knife, beginning with the posterior segment. The segments were then mounted serially with the anterior surface upwards. This procedure was quite simple until about segments 10 to 15 were reached, when it was found that the segments were so small and close together that the detachment of single ones was difficult and tedious, and also often unsatisfactory. Anterior to this point sections were therefore cut with a microtome, when required. Horizontal sections were necessary, however, to determine the structure of the uterus, *e.g.*, the presence, or absence, of anterior and posterior outpocketings, and certain other details.

EXTERNAL ANATOMY.

The largest specimen measured 114 mm. long, 22 mm. broad and 3·25 mm. thick, and the smallest 14 mm. long, 4·25 mm. broad and

1·75 mm. thick. Specimens less than 30 mm. long were immature. Most of the larger worms approximated the following dimensions:—Length 90 mm., breadth 20 mm., thickness 3 mm.; number of segments, about two hundred and fifty.

The following measurements show the size of our largest worm as compared with measurements made by Führmann and Collin of the same species:—

	Long	Broad	Thick
Führmann	50 mm.	18 mm.	3 mm.
Collin	70 mm.	26 mm.	5-6 mm. ?
Our specimen	114 mm.	22 mm.	3.25 mm.

The smallest specimen contained ninety segments, and the posterior extremity was much narrower than the middle of the worm, and was rounded; the last few segments were longer (0·25 mm.) than the posterior segments in full-sized worms. A considerable number of Oestrid larvae (*Gastrophilus* sp.) were found firmly attached to many of the worms.

Head. The head is always conspicuous; it is cuboid, with a truncate anterior extremity; the breadth is considerably greater than the length. In large worms measuring 90 mm. the head is about 2 mm. long and 3·25 mm. broad.

Suckers. The suckers, which are situated on the anterior surface of the head, are directed straight forward. They are about 0·7 mm. in diameter, and their cups are surrounded by a definite muscular rim having a diameter of about 200μ. The suckers were separated from one another by more or less well marked grooves.

Lappets. Immediately behind each sucker is a large lappet. The length and breadth of the lappets varies considerably, possibly owing to contraction during fixation, but when they are fully extended they measure about 1·25 mm. long, 1·75 mm. broad, and the distance between the bases of the two dorsal or two ventral lappets is about 0·6 mm. In some specimens the lappets were globular and filled with liquid.

Segments. The segments are very shallow and are imbricated. Posteriorly, the worm increases gradually in size, the greatest breadth being usually about 1 cm. from the posterior extremity; it must be remarked, however, that the general shape of the worm varies considerably in different individuals, possibly owing to different degrees of contraction during fixation (Plate XVII).

INTERNAL ANATOMY.

Muscular system. Both the longitudinal and transverse muscles are strongly developed, and in transverse sections of mature segments the thickness of the former is about 130μ, and that of the latter about 60μ (fig. 3). The dorso-ventral muscle bands are not so well developed. A short but powerful muscle connects the internal extremity of the cirrus pouch with the transverse muscles of the ventral surface.

Nervous system. There are three longitudinal nerves on each side, the median being far the most prominent. The other two, dorsal and ventral, are slightly lateral to the median nerve and close to the transverse muscular layer (figs. 1 and 3).

Excretory system. The water vascular system is enormously developed. On each side there are two vessels, a very large ventral vessel having a diameter of about 35μ, and a much smaller dorsal vessel which appears to be interrupted from time to time. The ventral vessel is internal to the dorsal vessel which lies over the median nerve trunk. The remarkable development of the water vascular system is one of the most striking features in sections of the worm (figs. 2 and 3).

Genitalia. At least the whole of the posterior half of the worm is sterile, exhibiting no trace of genitalia, and, as in none of the specimens examined was there any evidence that segments had been shed, it is probable that the worm is passed entire in the faeces.

Testes. These first appear about segment 4 or 5, and they disappear about segment 25. They attain their maximum development between segments 11 and 15, where each testis measures from about 55μ to 90μ by 30μ to 70μ. They occupy the entire medullary parenchyma between the ventral excretory vessel on one side, and the cirrus pouch on the other; they never cross the ventral excretory vessel. They usually lie three or four deep in the dorso-ventral direction, but the larger ones may be only one or two deep (fig. 1).

Vas deferens. After running laterally from the testes for a short distance, the vas deferens dilates into the outer seminal vesicle, which usually lies ventral to the cirrus pouch, although it was observed occasionally to lie dorsal or median to the latter structure. It then narrows and enters the cirrus pouch, where it again dilates to form the inner seminal vesicle. The cirrus pouch is remarkably

long, and passes dorsal to the ventral water vessel and median nerve to reach the edge of the segment (figs. 1 and 2). The cirrus is long, slightly coiled, and is armed with very minute spines. Packets of spermatozoa of various shapes and sizes, but usually oval with pointed extremities, are abundant in both the outer and inner seminal vesicles. In the majority of mature segments, the measurements of these various structures are approximately as follows:—

Length of outer vesicula seminalis	550μ
Greatest breadth of vesicula seminalis	150μ
Length of inner vesicula seminalis	700μ
Greatest breadth of vesicula seminalis	200μ
Total length of cirrus pouch	$1{,}000\mu$
Greatest breadth of cirrus pouch	100μ

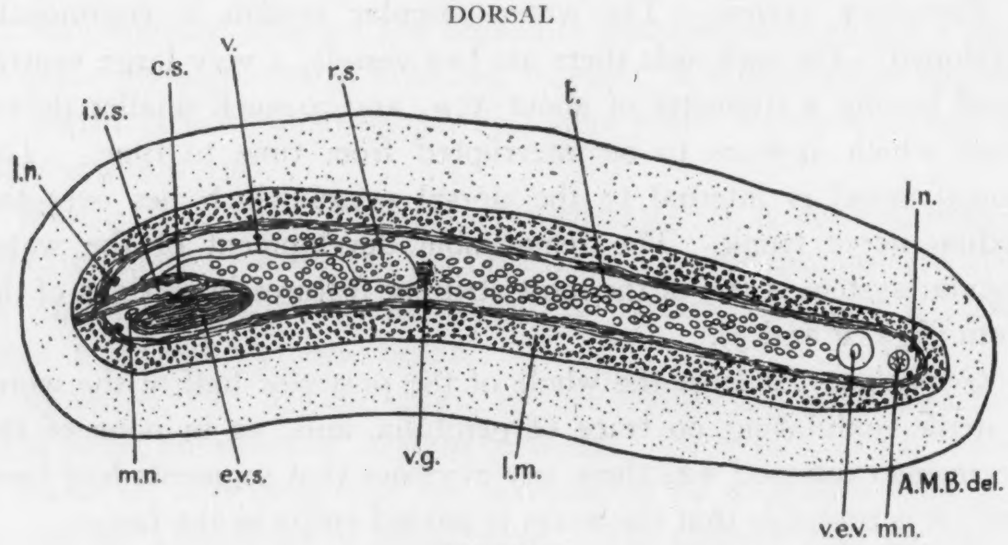


FIG. 1. *A. rhodesiensis.* Segment, viewed anteriorly, showing male genitalia. *c.s.*, cirrus sac; *e.v.s.*, external vesicula seminalis; *i.v.s.*, internal vesicular seminalis; *l.m.*, longitudinal muscles; *l.n.*, lateral nerves; *m.n.*, median nerve; *r.s.*, receptaculum seminis; *t.*, testes; *v.*, vagina; *v.e.v.*, ventral excretory vessel; *v.g.*, vitelline glands. × 40.

Ovary. This first appears about segment 24 and disappears about segment 34; it attains its maximum development about segment 30. The poral wing has a lateral diameter of about 1 mm. and the aporal wing of 2·2 mm. The median axis of the ovary is slightly cn the pore side. The ovary consists of a series of vertical, club-shaped columns arising from a ventral horizontal base. The largest column measures about 170μ dorso-ventrally and 60μ laterally. The columns decrease in size towards the periphery of the ovary (fig. 2). In the antero-posterior direction they are never more than two deep.

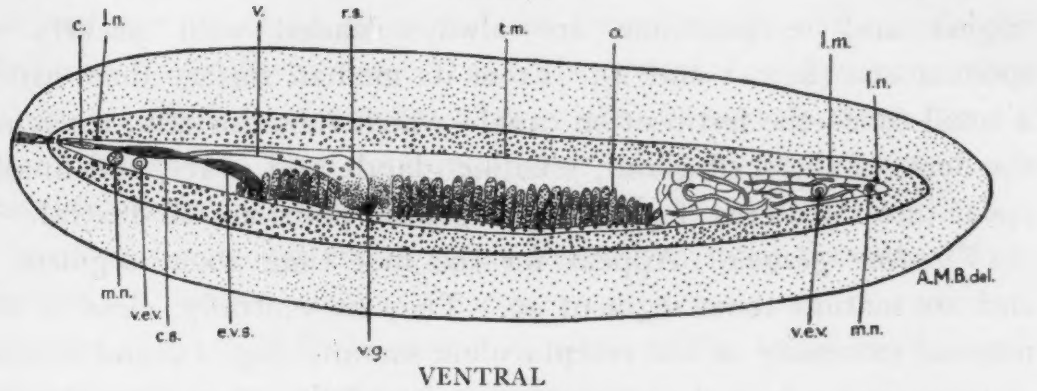


FIG. 2. *A. rhodesiensis.* Segment, viewed anteriorly, showing female genitalia. *c.*, cirrus; *c.s.*, cirrus sac; *e.v.s.*, external vesicula seminalis; *l.m.*, longitudinal muscles; *l.n.*, lateral nerves; *m.n.*, median nerve; *o.*, ovary; *r.s.*, receptaculum seminis; *t.m.*, transverse muscles; *v.*, vagina; *v.e.v.*, ventral excretory vessel; *v.g.*, vitelline glands. × 15.

Receptaculum and vagina. In segment 16 the vagina is well defined. From the pore it runs as a narrow tube ventral to the cirrus pouch for a short distance, then crosses it posteriorly to reach the dorsal surface. At this point it dilates and runs inwards just below the dorsal transverse muscle fibres, to enter the large receptaculum seminis. The receptaculum seminis is roughly club-shaped, with a greatly dilated internal extremity which is bent upon

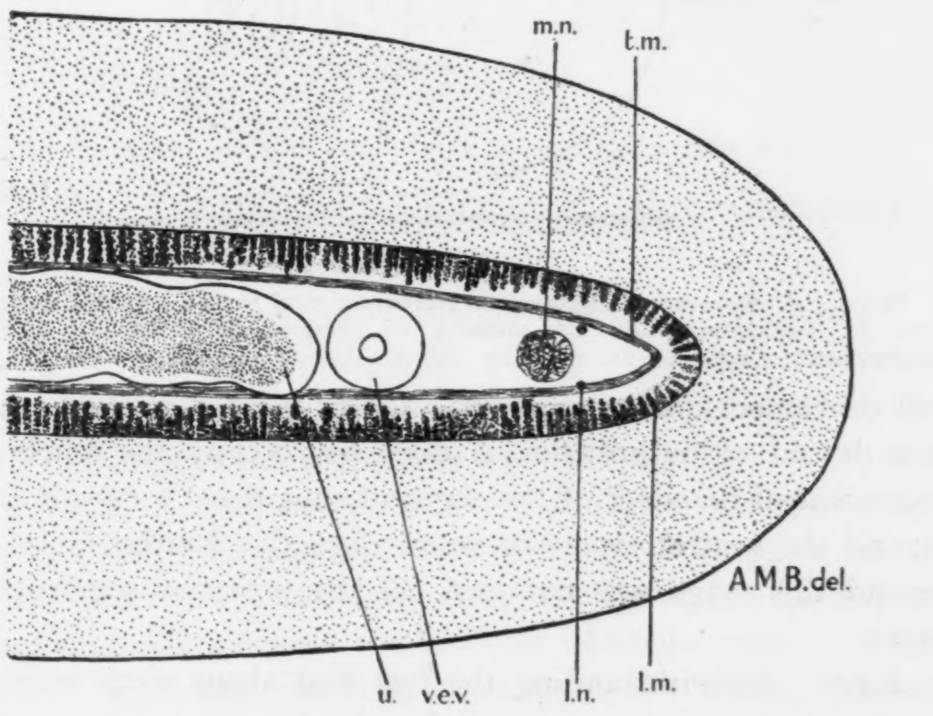


FIG. 3. *A. rhodesiensis.* Aporal extremity of segment, viewed anteriorly, showing uterus, longitudinal muscles, nerves and excretory vessels. *l.m.*, longitudinal muscles; *l.n.*, lateral nerves; *m.n.*, median nerve; *t.m.*, transverse muscles; *u.*, uterus; *v.e.v.*, ventral excretory vessel. × 40.

itself and almost reaches the ventral transverse muscle fibres. The vagina and receptaculum are always loaded with packets of spermatozoa (figs. 1 and 2). From its median surface there arises a small tube—the fertilisation canal—which runs dorsally, receiving the ducts of the shell gland, vitelline glands and ovary, and finally opens into the uterus (fig. 4). The genital pores are all dextral.

Vitelline glands. Appear for the first time about segment 7 and are mature about segment 40. They lie ventrally, close to the internal extremity of the receptaculum seminis (fig. 2), and consist of two wings which do not appear to be lobular as in some species of *Anoplocephala*.

Shell gland. As far as could be ascertained, it lies dorsal to the vitelline glands and is almost always obscured by them.

Uterus. Visible for the first time about segment 15 as a cell-string running across the segment. In segments 40 to 70 or 80 it is

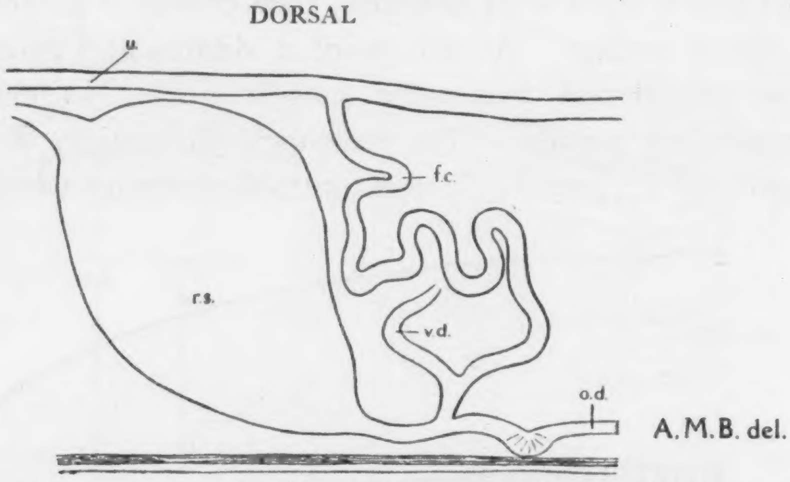


FIG. 4. *A. rhodesiensis.* Diagrammatic representation of fertilisation canal and connecting ducts. *f.c.*, fertilisation canal; *o.d.*, oviduct; *r.s.*, receptaculum seminis; *u.*, uterus; *v.d.*, vitelline duct. × 250.

well developed and contains ova; at this point it is a straight wide tube devoid of outgrowths, it does not occupy the whole of the dorso-ventral diameter of the segment, nor does it extend laterally beyond the ventral excretory vessel (fig. 3). Further development beyond this stage was not seen, all the posterior segments being sterile.

Eggs. Notwithstanding the fact that about sixty worms were examined, no mature eggs were found. Eggs varying in size from 12μ to 25μ were often found in the same uterus. The largest eggs

seen had apparently three envelopes, the outer measuring about 25μ, the middle about 20μ, and the inner, which was completely filled with the embryo, about 11μ. These were, however, very rare, and by far the largest number of eggs seen measured about 12μ to 15μ in diameter. They contained large oil and yolk globules. All attempts to discover a pyriform body failed.

Scattered amongst the eggs in the uterus there occurred large numbers of other cellular structures apparently of a nutritive character (fig. 5). They varied in size, within wide limits, and many seemed to be in process of degeneration.

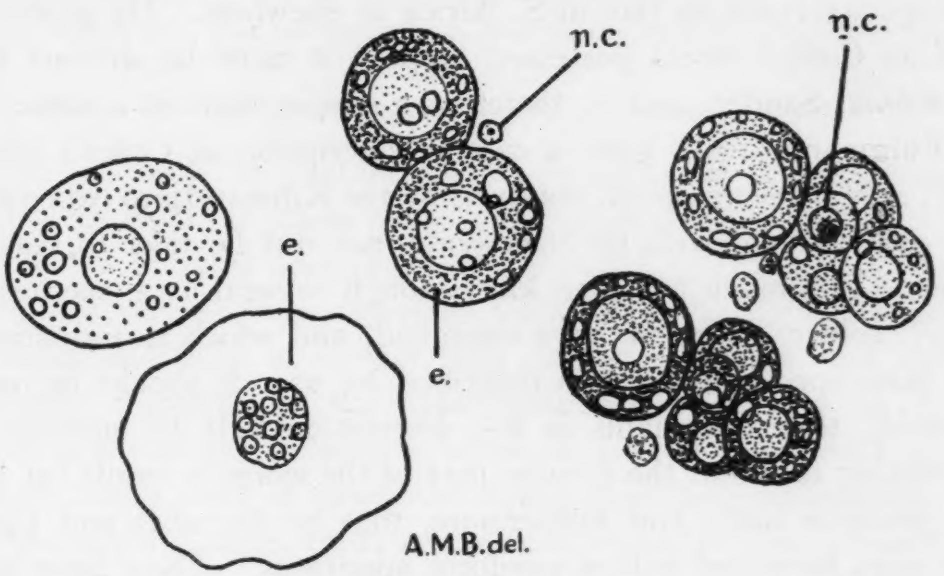


FIG. 5. *A. rhodesiensis.* Eggs and nutritive cells. *e.*, egg; *n.c.*, nutritive cells. × 730.

DIAGNOSIS. The following are the chief diagnostic characters:—

1. Presence of lappets.
2. Its large size and numerous segments.
3. The enormous development of the water vascular system and longitudinal musculature.
4. The large number of sterile segments.

Abildgaard, in 1789, described a cestode from a horse, to which he gave the name *Taenia magna*; this worm had no lappets behind the head. Zeder, in 1800, also described an equine tapeworm, which had no lappets behind the head, to which he gave the name *T. plicata*. Rudolphi, in 1808, referring to *T. zebrae*, Sander, collected from a zebra, placed it amongst the species *dubiae*, and stated that it had affinities with *T. plicata*. Presumably, therefore,

T. zebrae of Sander did not possess lappets behind the head. Later, Cobbold expressed the opinion that *T. plicata* was a synonym of *T. magna*, Abildgaard.

The genus *Anoplocephala* was established by E. Blanchard in 1848.

Collin (1891) gave a general description of a worm collected from an African zebra which resembled *A. perfoliata* in possessing lappets behind the head. He named the species *Taenia zebrae*.

Gough (1908) states that *A. magna* (Zeder), var. *pediculata*, Railliet, were found by him in the horse, donkey and zebra, and that this species is not so rare in S. Africa as elsewhere. He points out that as Collin's worm possessed lappets, it must be distinct from *T. zebrae*, Sander, and is, therefore, a species without a name.

Führmann (1910) gave a careful description of Collin's species of *T. zebrae* from material obtained by the Kilimandjaro expedition, but did not deal with the synonymy, nor did he refer to Gough's paper. Führmann has been kind enough to send us a specimen of his *A. zebrae*, which we have examined, and which is undoubtedly the same species as the one described by us. It should be noted, however, that Führmann in his description fails to mention the interesting fact that the greater part of the worm is sterile (at least the posterior half), and furthermore, that he describes and figures ripe eggs furnished with a pyriform apparatus. These have never been seen by us, notwithstanding the fact that we have examined, minutely, the uterus from the ripest segments of over twenty of our specimens and also that of the specimen Führmann was good enough to send us.

Douthitt, in 1915, stated that *A. plicata* (Zeder) and *A. zebrae* are synonyms of *A. magna* (Abildgaard), and draws no distinction between Sander's *T. zebrae* and Collin's *T. zebrae*. He was apparently unaware of Führmann's paper, as he makes no reference to it.

It is clear that the worm which Collin named *T. zebrae* differs from Sander's *T. zebrae*, which is apparently identical with *T. magna*, Abildgaard, in that Collin's species is lappeted, whereas Sander's is not. *T. zebrae*, therefore, is a synonym of *T. magna*, and Collin's worm is, as Gough says, a species without a name. We propose to designate it *A. rhodesiensis*.

II. *ANOPLOCEPHALA PERFOLIATA* (Goeze, 1782), Blanchard, 1848.

The museum of this School contains the following collection of lappeted *Anoplocephala* from horses and mules :—

HORSE A. Three specimens from Chesterfield, collected by A. W. Noel Pillers, December, 1909.

HORSE B. Eight specimens from Chesterfield, collected by A. W. Noel Pillers, July, 1910.

HORSE C. Four specimens from Sheffield, collected by A. W. Noel Pillers. No date.

HORSE D. Two specimens from Manititlan, Mexico. No further information.

MULE E. Ten specimens from Argentine, collected in 1917.

As a result of preliminary examination of the anatomy of specimens from the above sources, we reached the conclusion that a number of different species were represented. On further examination, however, we were impressed with the fact that great variations occurred not only in worms from the same source, but even in different segments of the same specimen. This led us to the conclusion that the differences which at first we considered to be of specific value were of inconstant occurrence, and consequently that *A. perfoliata* (Goeze, 1782) is a species which exhibits considerable variation.

In this paper we propose to re-describe the worm, drawing attention to the variations which may occur.

EXTERNAL ANATOMY.

The worms from the different sources were approximately the same size, varying from about 30 mm. to 45 mm. in length, except in the case of specimens from Horse B, which were fixed in a very extended condition and were of a gelatinous consistency. These were considerably longer, varying from 44 mm. to 70 mm. As a rule, the worms attain a maximum breadth of about 12 mm.

Head. This is prominent and almost cubical in shape; the length (2·5 mm.) is nearly equal to the breadth (3 mm.). In the specimens from Horse A the head was, however, distinctly broader (2·75 mm.) than long (1·5 mm.). The suckers and lappets resemble closely those of *A. rhodesiensis.*

Segments. The number of segments in an adult worm varies from about ninety to one hundred and thirty. The shape of the worm varies enormously, as will be seen in the photographs. Except that the worm is much less massive and consists of fewer segments than *A. rhodesiensis*, it exhibits no constant external difference from the latter species (Plate XVII).

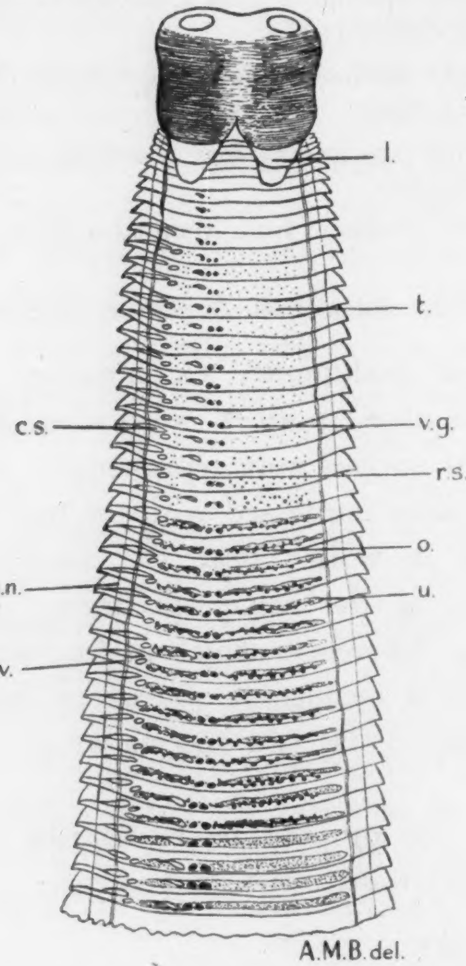


FIG. 6. *A. perfoliata.* Ventral view of anterior portion of a worm from Horse B; cleared in carbolic acid. *c.s.*, cirrus sac; *l.*, lappets; *m.n.*, median nerve; *o.*, ovary; *r.s.*, receptaculum seminis; *t.*, testes; *u.*, uterus; *v.e.v.*, ventral excretory vessel; *v.g.*, vitelline glands. × 6.

INTERNAL ANATOMY.

Muscular system. As in *A. rhodesiensis*, except that the longitudinal fibres are not so strongly developed.

Nervous system. The number of longitudinal nerves on each side varied. As a rule, there were three on each side, but in specimens from Horse B only the median nerve was constantly present, although the dorsal and ventral nerves were also seen in some segments. This variation was observed in the different

segments of the same worm, with the result that some segments exhibited only one nerve on each side, whilst in others three nerves were found on both sides, and in still others three nerves on one side and one on the other.

Excretory system. This differed from that of *A. rhodesiensis* only in that the vessels were not so large.

Genitalia. The segments become increasingly ripe towards the posterior extremity, and only a few sterile segments were found scattered here and there. This is in striking contrast to the long chain of sterile segments forming the posterior half of *A. rhodesiensis.*

Moreover, examination of the posterior extremities of worms from various horses left no reason to doubt that segments are shed.

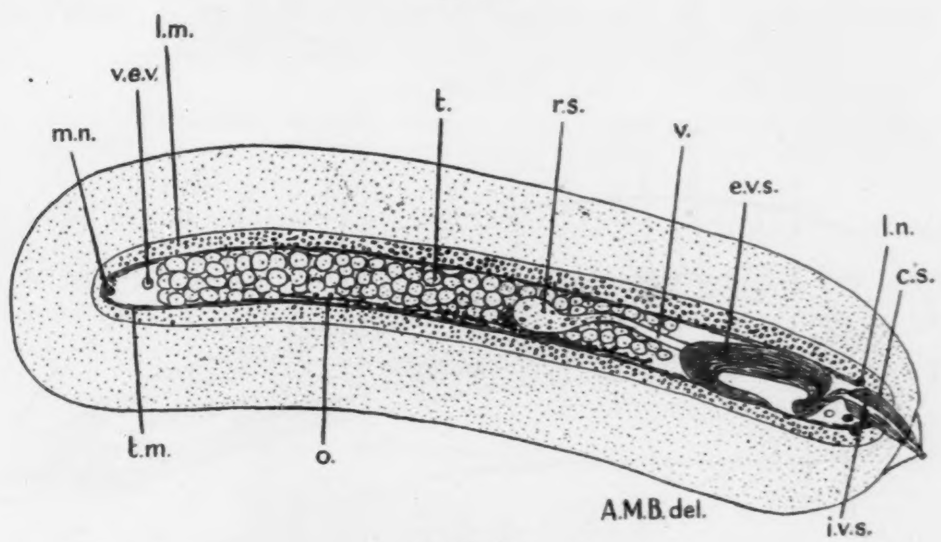


FIG. 7. *A. perfoliata.* Segment, viewed posteriorly, showing male genitalia. *c.s.*, cirrus sac; *e.v.s.*, external vesicula seminalis; *i.v.s.*, internal vesicula seminalis; *l.m.*, longitudinal muscles; *l.n.*, lateral nerves; *m.n.*, median nerve; *o.*, ovary; *r.s.*, receptaculum seminis; *t.*, testes; *t.m.*, transverse muscles; *v.*, vagina; *v.e.v.*, ventral excretory vessel. × 20.

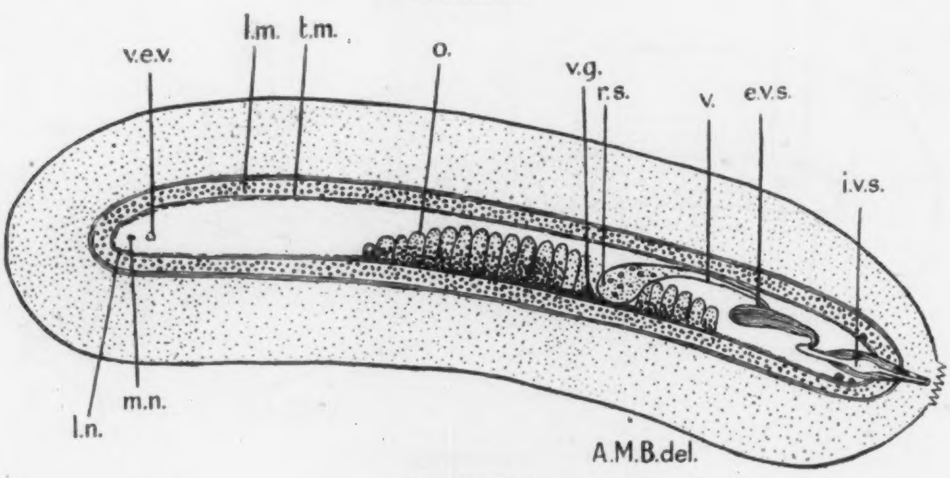
Testes. These first appear about segment 12 and disappear about segment 30. They attain their maximum development between about segments 17 and 22. In all the specimens examined, excepting those from Horse B, the fully developed testes occupied the whole parenchyma between the aporal excretory vessel and the cirrus pouch (fig. 7). In Horse B, whilst this state of things was occasionally found, the testes, as a rule, were fewer in number and more limited in distribution, being congregated mainly in the dorsal

portion of the parenchyma; they did not extend laterally nearly so far as the aporal water vessel. There appears to be no doubt that in old worms the testes degenerate and entirely disappear. No trace of testes were found in the worms from Horse A.

Vas deferens. The appearance of the internal and external seminal vesicles varied considerably, and they did not exhibit any constant relationship one to the other. The outer seminal vesicle was usually ventral to the inner seminal vesicle, but this was not invariably the case; sometimes the former lay directly internal to the latter, or even dorsal to it.

Ovary. This first appears about segment 25 and disappears about segment 45. It attains its maximum development about segment 37. The poral wing has a diameter of about half that of the aporal wing. In structure it resembles that of *A. rhodesiensis*

DORSAL



VENTRAL

FIG. 8. *A. perfoliata.* Segment, viewed posteriorly, showing female genitalia. *e.v.s.*, external vesicula seminalis; *i.v.s.*, internal vesicula seminalis; *l.m.*, longitudinal muscles; *l.n.*, lateral nerves; *m.n.*, median nerve; *o.*, ovary; *r.s.*, receptaculum seminis; *t.m.*, transverse muscles; *v.*, vagina; *v.e.v.*, ventral excretory vessel; *v.g.*, vitelline glands. × 20.

(fig. 8). As in the case of the testes, the ovaries had entirely disappeared in worms from Horse A.

Receptaculum and vagina. The vagina appears early and is well defined in about segment 8. These structures resemble in all respects those of *A. rhodesiensis.*

Vitelline and shell glands. Similar to those of *A. rhodesiensis.*

Uterus. The uterus appears very early, about segment 12, as a delicate cell-string running across the segment. It gradually

enlarges and attains its full development only in the last few segments, where it is a wide tube completely filling the medullary parenchyma, but only occasionally crossing the ventral excretory vessels. In the fully developed uterus there are numerous anterior and posterior outpocketings, so that in anterior or posterior views of whole segments the uterus appears to be composed of a number of separate compartments (fig. 9). Sections, however, showed clearly

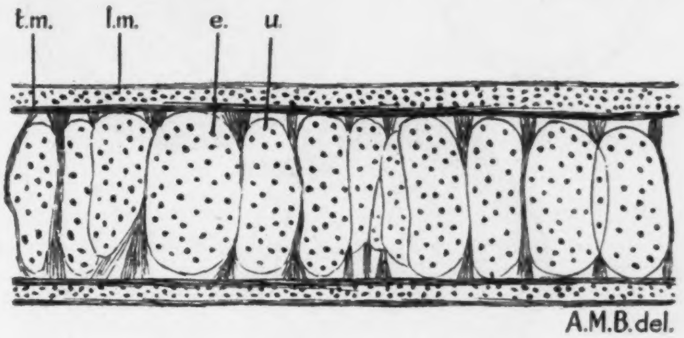


Fig. 9. *A. perfoliata.* Segment, viewed posteriorly, showing fully developed uterus. *e.*, egg; *l.m.*, longitudinal muscles; *t.m.*, transverse muscles; *u.*, uterus. × 40.

that the organ consisted of a central cavity with numerous anterior and posterior bulges between the dorso-ventral muscle fibres (fig. 10). To a certain extent there are bulges on the dorsal and ventral surfaces of the uterus, but they are not so prominent as those on the anterior and posterior surfaces. The degree of outpocketing varied in

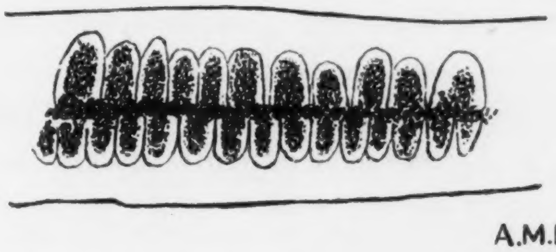


Fig. 10. *A. perfoliata.* Horizontal section of segment showing fully developed uterus. × 40.

different worms, sometimes being well marked and in other cases less obvious. Of the worms examined by us, the outpocketing was most marked in those from Mule E, and least marked in those from Horse B. Occasionally a well-developed uterus was seen which contained few or no eggs and a mass of debris.

Eggs. Fully mature eggs were found only in the last few segments. The diameter of the outer envelope was about 80μ, and that of the embryo about 16μ, whilst the length of the horns of the pyriform apparatus is about 18μ. Yolk granules about 7μ in

diameter occurred plentifully (fig. 11). As the egg matures, the middle envelope gradually shrinks, and its measurement is therefore of no value. In quite ripe eggs the horns of the pyriform apparatus

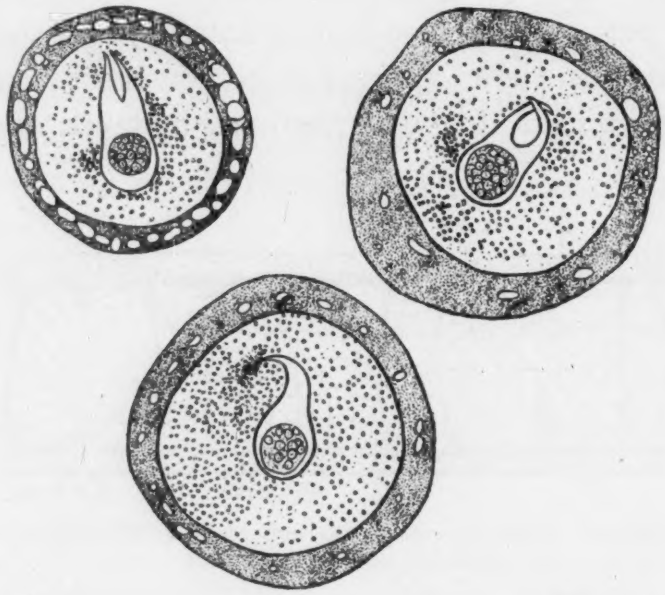


FIG. 11. *A. perfoliata.* Eggs showing pyriform apparatus. × 360.

are prolonged into very long, slender filaments which eventually unite with one another.

DIAGNOSIS. Führmann, as a result of a comparison between his own observations on the lappeted *Anoplocephala* from the zebra (called by him *A. zebrae*), and Kahane's description of *A. perfoliata*, gives the following points of difference between the two worms.

Cirrus pouch. In *A. zebrae* it extends beyond the longitudinal nerve and ventral water vessel, whilst in *A. perfoliata* it scarcely reaches the water vessel.

Vesicula seminalis. In *A. zebrae*, it is dorsal or ventral to the cirrus pouch, and in *A. perfoliata* it is posterior.

Ovary. Much more strikingly asymetrical in *A. zebrae* than in *A. perfoliata.*

We have carefully examined these points, and have reached the conclusion that they have no specific value. In the specimens of *A. perfoliata* examined by us, the cirrus pouch extended over the longitudinal water vessel and nerve to the edge of the segment, just as it does in the worm from the zebra. The relative position of the outer seminal vesicle and the cirrus pouch is inconstant, and finally

the aporal wing of the ovary is about twice the size of the poral wing in both worms.

In our experience, the only constant points of difference between the lappeted *Anoplocephala* of the zebra and horse, viz., *A. rhodesiensis* and *A. perfoliata*, are as follows:—

(1) *A. rhodesiensis* is much more massive than, and has almost twice as many segments as, *A. perfoliata*.

(2) The posterior half of *A. rhodesiensis* is entirely sterile, whereas in *A. perfoliata* the segments become increasingly ripe up to the posterior extremity of the worm.

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EXPLANATION OF PLATE XVII

Fig. 1. Photograph of *Anoplocephala rhodesiensis* showing bots attached. Natural size.

Fig. 2. Photograph of *Anoplocephala perfoliata* from Mule E, Horse B and Horse C, and of *Anoplocephala rhodesiensis* from a Zebra. (In order from left to right.) Natural size.

FIG. 1

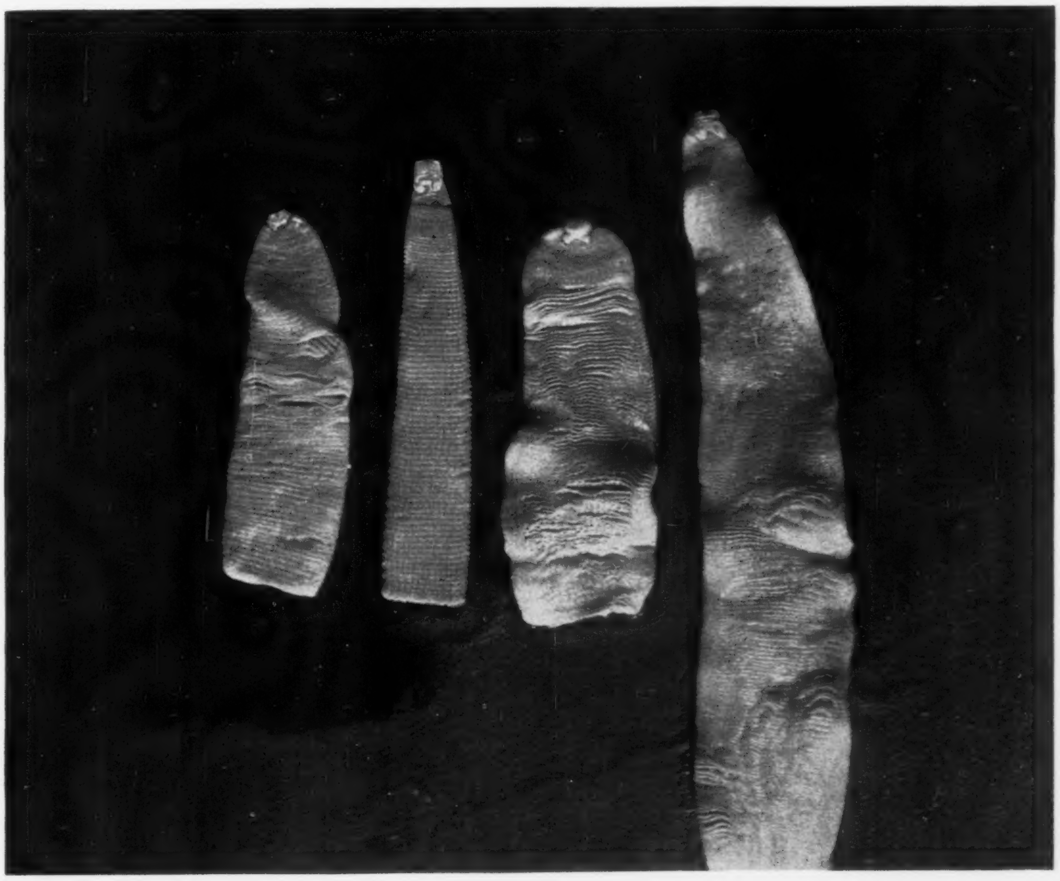

FIG. 2

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THE FEEDING HABITS OF *STEGOMYIA CALOPUS*, MEIGEN

BY

R. MONTGOMERY GORDON

AND

C. J. YOUNG

From the Laboratory of the Liverpool School of Tropical Medicine, Manáos

(*Received for publication* 28 *July*, 1921)

It has been stated by Marchoux and Simond (1906) that *Stegomyia calopus*, under normal conditions, that is, while at liberty, ceases to bite man during the day after the first six or eight days of its existence in the perfect state, but that after the eighth day it is sometimes observed to bite towards 6 p.m. before nightfall. They also state that yellow fever is not contracted during the day, but only 'à la chute du jour où pendant la nuit.' 'Nous avons en effet constaté expérimentalement qu'à la période de sa vie où il possède le pouvoir infectant, le *Stegomyia fasciata* en liberté ne cherche pas à piquer l'homme entre 7 heures du matin et 5 h. ½ du soir. La transmission est donc nocturne.' This they held to account for the fact that the inhabitants of Petropolis when visiting Rio only during the day did not contract yellow fever. In their experiments, however, the mosquitoes were confined in a screened room. Seidelin and Connal (1914) and Macfie (1915-16) showed that *S. calopus* would bite at any hour irrespective of age, when in captivity.

According to Marchoux and Simond (1906) the minimum interval between the date on which *S. calopus* acquires the infection and that on which it becomes infective is twelve days.

The following experiments were undertaken with a view to investigating the feeding habits under as natural conditions as possible. They were carried out in Manáos.

All the mosquitoes were hatched in the laboratory and kept in wire gauze cages, males being always present. Each female was removed from the stock cage in a glass tube and allowed to feed to repletion on one of us during the hours of daylight. After feeding they were 'marked' by amputating the hindlegs through the tibiae,

but in a few instances some part of the femur was accidentally removed. This method of 'marking' is considered sufficiently distinctive as wild specimens of *Stegomyia*, observed by us at other times, have never shown this mutilation. After feeding they were kept for not less than fourteen days, sugar being available as food, and during the last two or three days of this period were again given an opportunity to bite, also during daylight. They were then released under the conditions described below and during the four succeeding days, in the place where they had been released, the mosquitoes biting us were observed for one hour each during the day and night. The observations at night were made by electric light. No unmarked females were released along with the 'marked.'

Three experiments were carried out.

Experiment I. Date: 23rd March to 16th April, 1921. Sixty female *Stegomyia* were fed a first time and 'marked' between 23rd and 28th March. Of these thirty-three survived, and were offered a second feed on the 11th and 12th of April; thirty fed and three refused to feed. Two escaped after feeding. The remaining thirty-one females along with twelve males were released at 7 p.m. on the 14th April in a first-floor bedroom of about 14 ft. by 12 ft. by 10 ft. This room was in use, the occupant using a mosquito net at night; it had two unscreened windows which were constantly open, and the mosquitoes also had free access to other parts of the house. A glass jar containing water was placed in the room, but no eggs were deposited in it up to the 23rd April. 'Marked' mosquitoes were released after feeding.

Observations were made as follows:—

Date	April ...	15		16		17		18	
Time	P.M. ...	12.30 to 1.30	8.30 to 9.30	12.30 to 1.30	8.30 to 9.30	12.30 to 1.30	8.30 to 9.30	12.30 to 1.30	8.30 to 9.30
S. calopus biting ...	'Marked'...	3	0	2	0	0	0	0	0
	Unmarked...	3	0	0	0	0	0	0	0

NOTE.—In addition, one of us was bitten by a 'marked' mosquito at 7.30 a.m. on the 15th.

Experiment II. Date: 5th to 29th April, 1921. Sixty female *Stegomyia* were fed a first time and 'marked' between the 5th and 11th April. Of these twenty-three survived. They were offered a second feed on the 23rd and 24th April; twenty-one fed and two refused. They were released with about twelve males at 5 p.m. on the 25th in a first-floor bedroom in a different part of the town frcm Experiment I. This room was about 20 ft. by 14 ft. by 12 ft. in size, was in use, the occupant using a mosquito net at night, had four large windows constantly open, and the mosquitoes had free access to other parts of the house.

Observations were made as follows:—

Date ...	April ...	25	26		27		28		29
Time ...	P.M. ...	8—9	12—1	8—9	12—1	8—9	12—1	8—9	12—1
S. calopus biting ...	'Marked'...	0	*0*	0	*0*	0	*0*	0	*0*
	Unmarked...	0	0	2	0	0	0	0	0

Experiment III. Date: 1st May to 3rd June, 1921. Seventy female *Stegomyia* were fed a first time and 'marked' between 1st and 14th May. Of these fifty survived. Offered second feed on 28th, 29th and 30th May; forty-three fed and seven refused. These fifty were released along with about twelve males at 3 p.m. on the 30th May in a ground-floor room behind the laboratory, about 17 ft. by 10 ft. by 15 ft. in size and opening directly to the outside. This room had one window, the upper part of which was imperfectly screened and the lower part had wooden slats, the apertures between these allowing free passage to mosquitoes. The door was open all day and for one hour at night when observations were made. Otherwise the room was not used at night. A jar of water was placed in the room, and some eggs were found on 31st May. 'Marked' mosquitoes were released after feeding.

Observations were made as follows :—

Date ...	May ...	30	31		June 1		2		3
Time ...	P.M. ...	8.30 to 9.30	1—2	8.30 to 9.30	1—2	8.30 to 9.30	1—2	8.30 to 9.30	1—2
S. calopus biting	'Marked'...	3	*7*	3	*2*	0	*1*	0	*0*
	Unmarked...	1	4	4	1	3	0	0	5

NOTE.—Each of us was bitten in the laboratory by a 'marked' *Stegomyia* on the 7th June, one at 9 a.m. and the other at 4 p.m.

SUMMARY

Experiment I. Thirty-one 'marked' female *Stegomyia* were released at night not less than fourteen days after their first blood meal. During the succeeding four days, five 'marked' and three unmarked fed during daylight. None were observed to feed at night.

Experiment II. With the exception of two unmarked *Stegomyia*, none were observed to feed.

Experiment III. Fifty 'marked' female *Stegomyia* were released during daylight not less than fourteen days after their first blood meal. During the succeeding four days, ten 'marked' and ten unmarked fed during daylight, and six 'marked' and eight unmarked fed during the night.

CONCLUSION

Stegomyia calopus females will bite either by day or night, over fourteen days after their first blood meal, while under no artificial restraint and having opportunities of selecting day or night for feeding.

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NOTE ON A CASE OF LEPROSY

BY

WARRINGTON YORKE

AND

S. ADLER

(Received for publication 2 August, 1921)

PLATE XVIII

Native of Hong Kong, age 45. Came to the outpatient department of Tropical School, 29th July, 1921, complaining of feeling ill, ulceration of face and generalised skin eruptions.

PRESENT CONDITION. The appearance of the face at once suggested leprosy. Both *alae nasi* were swollen and ulcerated, and there were fairly well developed nodules on the chin, forehead and cheeks. There was an extensive raised, ham coloured, rash on the arms, forearms, trunk and legs. The affected areas of skin were not anaesthetic except for small patches on the inner side of the left leg and foot and on the outer side of the right leg. No thickening of the superficial nerve trunks was observed. Scrapings from the skin lesions and from the *alae nasi* showed very numerous *lepra bacilli*.

HISTORY. The most interesting feature of this case is its history. The patient arrived in England in 1912 in good health, and has been employed until a short time ago as a laundryman in Cardiff. It was not until 1916—four years after coming to England—that he first noticed small spots on the left side of the face. No further change was observed until twelve months ago, when the ham-coloured eruption appeared on the trunk and upper and lower limbs. Five months ago he noticed for the first time the swelling of the *alae nasi*.

There is no evidence that the case had been diagnosed before we saw him: the patient and his friends were quite unaware of the fact that it was leprosy.

EXPLANATION OF PLATE XVIII

Photograph of a case of leprosy showing swelling and ulceration of *alae nasi* and nodules on various parts of face.

PLATE XVIII

C. Tinling & Co., Ltd., Imp.

NOTES ON SOME FUNGAL INFECTIONS IN WEST AFRICA

BY

J. W. S. MACFIE

(*Received for publication* 24 *August*, 1921)

CONTENTS

Fungal infections are abundant in West Africa, but hitherto comparatively little attention has been devoted to them. Brief notes are given in this paper on a few cases which have recently come under our notice at Accra in the Gold Coast.

The part played by the fungi of the Genus *Monilia* in the diseases from which the patients were suffering is obscure. Such fungi are undoubtedly abundant in the tropics, and contamination with them must be guarded against; it is also true that they are not infrequently present in small numbers in the faeces of apparently healthy individuals. Their occurrence in great quantities is, however, a different matter. No evidence is brought forward in support of the view that the species of *Monilia* described in this paper were the sole cause of the dysentery and diarrhoea with which they were associated, indeed there was evidence that the cases referred to in Section II were due primarily to a dietetic deficiency, but it is maintained that they were the cause of some of the symptoms. For this reason, and because the intestinal disturbances which permit of their multiplication may be of profound significance, their recognition and investigation is of importance.

I. A FUNGUS OF THE GENUS *MONILIA* RECOVERED FROM A PATIENT SUFFERING FROM DYSENTERIC DIARRHOEA

Towards the end of the year 1920 there occurred at Accra a considerable number of cases of dysenteric diarrhoea, the cause of which was obscure. From one such case, a European man about forty years of age, the *Monilia* was isolated, of which the following is a short description. The sample of faeces from which the fungus was recovered contained much blood and mucous, but no amoebae and no other parasite to which a pathogenic rôle could be assigned; it contained, however, a considerable number of yeast-like cells. From the same case, a week later, Dr. J. F. Corson isolated a bacillus which gave the reactions of Morgan's bacillus.

Several species of the Genus *Monilia* have been isolated from human faeces in various parts of the world, but especially in the tropics, and some of them have been regarded as being the cause, either directly or indirectly, of intestinal disease. Similar fungi are frequently found in small numbers in specimens of faeces in West Africa, and in diarrhoeic stools are sometimes very numerous. With regard to the species isolated from this case of dysenteric diarrhoea at Accra it is not possible to say if it was pathogenic, but it may be noted that it closely resembled *M. tropicalis*, one of the species which has been found to be present in sprue (Castellani, 1920).

The Organism. The *Monilia* found in this case was isolated in a culture of the faeces on neutral-red lactose bile-salt agar. It was Gram-positive and not acid fast. It grew well on most solid media, and on glucose agar produced within twenty-four hours an abundant creamy-white growth. Under anaerobic conditions growth was less abundant and less rapid. It grew freely both at 37° C. and at the temperature of the laboratory (about 26° C.). Gelatin and blood serum were neither liquefied nor stained. In broth and peptone water a whitish deposit was thrown down, whilst the media themselves remained clear; in both a surface pellicle was formed. It produced an abundant white growth on potato, which later developed a white efflorescence; the medium was not stained. On solid media the growth was mainly composed of yeast-like cells, but a few branched septate hyphae were usually present; in fluid media the hyphae sometimes predominated.

Its qualitative bio-chemical reactions may be tabulated as follows, the symbols representing:—A = acidity; G = gas; s = slight; O = neither acid nor gas.

Arabinose	O	Inulin	O
Rhamnose (isodulcite) ...	O	Amygdalin	O
Galactose	AGs	Helicin	O
Glucose	AG	Phlorrhizin	O
Laevulose	AG	Salicin	O
Mannose...	O	Glycerol	O
Lactose	O	Erythrol	O
Maltose	AG	Adonitol	O
Saccharose	AGs	Dulcitol	O
Raffinose...	O	Inosite	O
Amylum	O	Mannitol	O
Dextrin	O	Sorbitol	O
Glycogen	O		

If the cultures were kept, the acidity produced in the five sugary media indicated tended to be superceded by alkalinity; this change began to occur early, usually in less than a week. No change was produced in Litmus milk at first, but after a week or ten days a slight alkalinity was sometimes noticed; no clot was formed, and the medium was neither decolourized nor peptonized. Indol was not produced in peptone water.

As gas was produced in Glucose, Laevulose, Maltose, Galactose, and Saccharose the organism comes into the fifth group of species of *Monilia*, the *Tropicalis* group, according to the classification of Castellani and Chalmers (1919). The more important bio-chemical reactions of the species in this group are shown in Table I. It will be noted that the species here described differs in its reactions in Mannitol and Dextrin from *M. enterica*, *M. insolita*, *M. paratropicalis*, and *M. pulmonalis*. From *M. faecalis* it may be distinguished by the fact that it does not decolourize Litmus milk, and does not stain blood serum brown; and from *M. metatropicalis* by the fact that it does not clot milk. As regards *M. nivea*, the fact that neither acid nor gas is produced in Raffinose is a point of distinction, and it may be noted also that our species produces only a slight amount of gas in Galactose and forms a pellicle on the surface of broth, reactions which are not found in the case of *M. nivea*. Our organism closely resembles *M. tropicalis*, the greatest divergence being in the reaction in milk. It is said that by *M. tropicalis* 'Litmus milk is generally rendered acid but is not

clotted,' a statement which would seem to imply that the production of acid is not constant nor characteristic. If this is so, the two species appear to be identical, excepting that in the case of our organism a pellicle is formed in broth.

TABLE I.

Species of the Genus *Monilia* belonging to the *Tropicalis* group.

Species of *Monilia*	Litmus milk	Glucose	Laevulose	Maltose	Galactose	Saccharose	Mannitol	Dextrin	Raffinose	Arabinose	Broth
M. enterica	O/Alk	AG	AG	AG	AG	AG	As	As	O	O	C
M. faecalis	A/DPs	AG	AG	AG	AGs	AGs	O	O	O	O	C
M. insolita	As/Alk	AG	AG	AG	AG	AG	As	O	O	O	C
M. metatropicalis	AC	AG	AG	AG	AG	AG	O	O	O	O	C
M. nivea	O/Alk	AG	AG	AG	AG	AGs	O	O	AG	O	C
M. paratropicalis	As/Alk	AG	AG	AG	AG	AG	O	Avs	O	O	CTP
M. pulmonalis	O/AlkD	AG	AG	AG	AGs	AG	Avs	O	A	AGs	CTP
M. tropicalis	A	AG	AG	AG	AGs	AGs	O	O	O	O	C
Accra case : sputum and pleural cavity (*M. accraensis*)	O/Alk	AG	AGs	AGs	AG	AG	O	O	O	O	C
Accra case : dysenteric faeces ...	O/Alk	AG	AG	AG	AGs	AGs	O	O	O	O	CTP

A = acidity; Alk = alkalinity; C = clot (milk), clear (broth); CTP = clear, then pellicle; D = decolourized; G = gas; O = neither acid nor gas; P = peptonized; s = slight; vs = very slight.

Finally it may be noted that this organism closely resembles a species of *Monilia* (*M. accraensis*) recently found by us in the sputum and pleural cavity of a patient suffering from tuberculosis at Accra (1921). The chief points of distinction are that the intestinal species produces only a slight amount of gas in Galactose and Saccharose, and forms a pellicle on broth; whereas the pulmonary species produces much gas in Galactose and Saccharose but only little in Laevulose and Maltose, and does not form a pellicle on broth.

SUMMARY

From the faeces of a European with dysenteric symptoms a fungus of the Genus *Monilia* was isolated. This organism belongs

to the *Tropicalis* group, and appears to resemble most closely *M. tropicalis* (Castellani, 1909).

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MACFIE, J. W. S., and INGRAM, A. (1921). Bronchomoniliasis Complicating Pulmonary Tuberculosis in a Native of the Gold Coast, West Africa. *Annals Trop. Med. & Parasitol.*, XV, pp. 53-58.

II. TWO FUNGI OF THE GENUS *MONILIA* RECOVERED FROM AFRICANS SUFFERING FROM A PECULIAR FORM OF DIARRHOEA

There occurs among the natives at Accra a well defined form of persistent diarrhoea which has been considered by some of the medical practitioners in the Gold Coast to be akin to sprue. The stools are bulky, frothy, and generally canary-yellow coloured; the tongue is red, fissured, and eroded; and the patients are wasted—a condition which is often masked by oedemas of the limbs and by ascites. The faeces in such cases usually teem with yeast-like cells which on cultivation are found to be stages of fungi of the Genus *Monilia.* The following are short descriptions of the organisms isolated from two such cases.

FIRST CASE.

The patient, a native man about twenty-seven years of age, was suffering from an obstinate diarrhoea, and was weak and wasted. His tongue was red, irregularly fissured, indented by the teeth, and partially eroded; the throat also was red. The faeces were canary-yellow coloured and frothy; yeast-like cells were extremely abundant in them, and *Entamoeba coli* and *Blastocystis enterocola* were also present.

The Organism. The *Monilia* in this case was isolated from a culture of the faeces on neutral-red lactose bile-salt agar. It was Gram-positive and not acid fast. It grew well on most solid media, and on Glucose agar produced within twenty-four hours an abundant white growth, very fluid in consistence, and with a dull pellicle-like surface. The yeast-like cells, which composed the greater part of the growth, were oval and somewhat elongated; the average

measurements of ten cells were, length $4{\cdot}5\mu$, breadth $1{\cdot}6\mu$. Under anaerobic conditions growth was less abundant and less rapid. Gelatin and blood serum were neither liquefied nor stained. In broth and peptone water a whitish deposit was thrown down, and the medium remained clear; in broth a surface pellicle was formed. On potato a dull white growth was developed which later showed a white efflorescence; the medium was not stained. On solid media the growth was mainly composed of yeast-like cells, but a few branched, septate hyphae were also present; in fluid media hyphae sometimes predominated.

The qualitative bio-chemical reactions of this *Monilia* may be tabulated as follows:—

Arabinose	O	Inulin	O
Rhamnose (isodulcite) ...	O	Amygdalin	O
Galactose	O	Helicin	As
Glucose	AG	Phlorrhizin	O
Laevulose	AG	Salicin	O
Mannose...	O	Glycerol	O
Lactose	O	Erythrol	O
Maltose	AGs	Adonitol	O
Saccharose	AG	Dulcitol	O
Raffinose...	AGs	Inosite	O
Amylum	O	Mannitol	O
Dextrin	AG	Sorbitol	O
Glycogen	O		

The symbols representing: A = acidity; G = gas; s = slight;
O = neither acid nor gas.

In the media in which acidity was produced the reaction tended after a few days to be succeeded by alkalinity. No change was produced in Litmus milk. Indol was not produced in peptone water.

As gas was produced in Dextrin as well as in other media the organism comes into the ninth group of species of *Monilia*, the *Pseudolondinensis* group, according to the classification of Castellani and Chalmers (1919). Two species belong to this group, namely, *M. pseudolondinensis*, Cast., and *M. pseudolondinoides*, Cast., which appear to differ only in their actions on Litmus milk. The more important bio-chemical reactions of these species and of the organism just described are given in Table II; it will be noted that

the latter species differs from the other two in its actions on Galactose, Saccharose, and Raffinose. These differences are important, and since the classification of these fungi is at present

TABLE II.
Species of the Genus *Monilia* belonging to the *Pseudolondinensis* group.

Species of *Monilia*	Litmus milk	Glucose	Laevulose	Maltose	Galactose	Saccharose	Raffinose	Dextrin
M. pseudolondinensis, Cast.	O	AG	AG	AG	AG	O	O	AG
M. pseudolondinoides, Cast.	AC	AG	AG	AG	AG	O	O	AG
M. africana, sp.n.	O	AG	AG	AGs	O	AG	AGs	AG

A = acid; G = gas; s = slight; O = neither acid nor gas; C = clot.

based on such bio-chemical reactions, the organism described here must be regarded as a new species. For it, therefore, the name *Monilia africana* is proposed.

SECOND CASE.

The patient, an adult native man, a Moshi, was suffering from persistent diarrhoea accompanied by ascites and oedema of the face, especially the left parotid area, the lumbar region, and the penis. There was no oedema of the legs. The faeces were semi-fluid, pale canary-yellow coloured, and frothy; they contained very numerous yeast-like cells.

The Organism. The *Monilia* in this case was isolated from a culture of the faeces on neutral-red lactose bile-salt agar. The colonies of yeast-like cells were rather slow in appearing, being detected first after forty-eight hours' incubation. It was Gram-positive and not acid fast. It grew well on most solid media, spreading as a thin film, and on Glucose agar produced within twenty-four hours an abundant white growth. The yeast-like cells which composed the greater part of this growth were, as in the previous case, somewhat elongated. Under anaerobic conditions growth was slower. Gelatin and blood serum were neither liquefied nor stained; the growth on gelatin was slow. In broth and peptone water a whitish deposit was thrown down, the medium remained

clear, and no pellicle was formed. On potato an abundant whitish growth was produced, and the medium was not stained. On solid media the growth was composed mainly of yeast-like cells, but a few branched, septate hyphae were also present; in fluid media hyphae sometimes predominated.

The qualitative bio-chemical reactions of this *Monilia* may be tabulated as follows:—

Arabinose	O	Inulin	O
Rhamnose (isodulcite) ...	O	Amygdalin	O
Galactose	A	Helicin	As
Glucose	AGs	Phlorrhizin	O
Laevulose	AGs	Salicin	As
Mannose...	O	Glycerol	O
Lactose	O	Erythrol	O
Maltose	A	Adonitol	O
Saccharose	O	Dulcitol	O
Raffinose...	O	Inosite	O
Amylum	O	Mannitol	O
Dextrin	O	Sorbitol	O
Glycogen	O		

The symbols representing: A = acidity; G = gas; s = slight; O = neither acid nor gas.

In the media in which acidity was produced the reaction tended after a few days to be succeeded by alkalinity. No change was produced in Litmus milk. Indol was not produced in peptone water.

As gas was produced in Glucose and Laevulose only, the organism comes into the second group of species of *Monilia*, the *Krusei* group, according to the classification of Castellani and Chalmers (1919). Two species are included in this group, namely, *M. krusei*, Cast., and *M. parakrusei*, Cast., which appear to differ only in their actions on Litmus milk. The more important bio-chemical reactions of these species and of the organism just described are given in Table III; it will be noted that the latter species differs from the other two in its actions on Maltose and Galactose besides in several minor points. These differences, according to the system of classification at present in vogue, are sufficient to justify the erection of a new species, and, therefore, although the number of species of the Genus *Monilia* is already embarrassingly large, we propose for this organism the name *Monilia enterocola*.

TABLE III.
Species of the Genus *Monilia* belonging to the *Krusei* group.

Species of *Monilia*	Litmus milk	Glucose	Laevulose	Maltose	Galactose	Saccharose
M. krusei, Cast.	O	AG	AG	O	O	O
M. parakrusei, Cast.	AC	AG	AG	O	O	O
M. enterocola, sp.n.	O	AGvs	AGs	A	A	O

A = acid; G = gas; s = slight; vs = very slight; O = neither acid nor gas; C = clot.

SUMMARY

From the faeces of two Africans suffering from a peculiar form of diarrhoea two fungi of the Genus *Monilia* were isolated, both of which appear to be hitherto undescribed species. The one belongs to the *Pseudolondinensis* group, the other to the *Krusei* group of Castellani and Chalmers. The names *Monilia africana* and *Monilia enterocola*, respectively, are proposed for these organisms.

III. A NOTE ON A CASE OF OTOMYCOSIS

Otomycosis is said to be not uncommon in the tropics. It may be caused by a considerable number of different fungi, and according to Castellani and Chalmers (1919), 'if they grow superficially, they cause no symptoms; but if they penetrate into the mucous membrane, they give rise to itching, and sometimes to pain.'

The patient whose case is the subject of this note was a European lady who consulted Dr. C. V. Le Fanu at Accra in the Gold Coast Colony, West Africa, on account of pain and irritation in the ear. The symptoms had existed for at least a month, but although they caused no little discomfort, there was no deafness. On examination Dr. Le Fanu found that the external auditory meatus was unusually narrow, but widened out at its inner end so as to form a small chamber immediately external to the drum of the ear. From a patch on the vault of this chamber, close to the drum of the ear, the fungus

was growing and hanging down like a veil. It may be said at once that the condition was rapidly relieved, and apparently cured, by an application containing as its principal constituent salicylic acid.

The fungus, which grew readily on Sabouraud's maltose agar and was easily obtained in pure culture on this medium, appeared to belong to the Genus *Sterigmatocystis*, Cramer 1859. Two species of this genus have been found in cases of otomycosis, namely, *S. antacustica* and *S. nidulans*, but the characters of both, as given in the descriptions to which I have access, differ slightly from those of the fungus isolated at Accra. The exact determination of the species of such a fungus is a matter for a mycologist. I shall, therefore, restrict myself to recording certain characters which may enable those who have made a special study of these fungi to place it more exactly.

Cultures. On Sabouraud's maltose agar the growth of the fungus was rapid and spreading; at first yellowish-white and felt-like, then slightly fluffy with the development of upstanding conidiophores, then speckled with dark brown points when the conidiophores began to develop their spores, and finally dark brown or almost black all over, resembling a mass of soot. On Glucose agar the initial growth at a temperature of 28° C. was almost white, with a somewhat puckered and wrinkled surface, but within twenty-four hours became yellowish, and began to show upstanding, white conidiophores. On the following day the whole surface of the medium was covered by a yellow, wrinkled, felt-like growth, on which were very many conidiophores, some already dark brown in colour. On the third day the whole surface of the medium looked as if it had been thickly dusted with soot. Growth, therefore, was rapid and abundant at 28° C., the temperature of the laboratory; it was, however, even more rapid at 37° C. In peptone water the fungus grew mainly on the surface, but detached fragments in the fluid produced delicate networks of hyphae which sometimes resembled puff-balls. Dark spores were formed on the conidiophores at the surface. In glucose peptone water acid was produced, but no gas. On blood serum growth was rather slow, the colonies were white, and the black spore-bearing conidiophores did not develop for a long time and were relatively scanty. Eventually the medium was liquefied. In a

gelatin stab culture there was no deep growth, and no liquefaction. A white surface growth developed with dark sooty grains, and later, just below the surface, there formed compact cerebriform whitish masses of the fungus. On potato growth was rapid and abundant; at first a yellowish felt-work, finally a sooty mass. In Litmus milk acid and clot were produced. The growth was mainly at the surface, was yellowish, and developed the usual dark brown sooty appearance.

Mycology. All the growths showed septate, branched hyphae of varying diameter. The hyphae appeared colourless when seen with a microscope. The lengths of the interspaces were very variable. In fluid media, such as glucose peptone water, chlamydospores were numerous in the surface felt-like growth. The conidiophores were erect. In cultures they were raised about 1 mm. above the level of the medium, but in the ear of the patient they appeared to be considerably longer. They were white on first appearance, but darkened later. The diameter of the stem was variable, but averaged about 14μ. The head was almost spherical, slightly broader than long, its diameters averaging 40μ and 37μ respectively; it was covered almost completely by sterigmata, only a very narrow zone at the proximal end, at the insertion of the stalk, being free from them. Both primary and secondary sterigmata were present; the primary sterigmata were about 12μ long (average of ten), the secondary about 8μ long (average of ten). There were usually four secondary sterigmata on each primary sterigma. The spores were dark brown in colour, and spherical in shape; diameter 4μ to $5{\cdot}2\mu$, average $4{\cdot}5\mu$.

Animal inoculations. Two wild *Mus rattus* were given intra-peritoneal inoculations of an emulsion of a small fragment of the original culture in normal saline. No ill-effects were observed to follow. A little of the same culture was applied to the external auditory meatus of a pouched rat (*Cricetomys gambianus*), a sheep, and a small monkey (*Cercopithecus patas*) after scarification, but no otomycosis was produced.

REFERENCE

CASTELLANI, A., and CHALMERS, A. J. (1919). *Manual of Tropical Medicine*, Third Edition, p. 2012. London: Bailliere, Tindall and Cox.

IV. TONSILLAR NOCARDIOMYCOSIS

One case of tonsillar nocardiomycosis has been met with at Accra. The patient, a European man, about thirty-two years of age, showed a number of small white concretions in crypts of both tonsils. The throat was not inflamed, and there was neither pain nor discomfort; but the presence of the concretions had been detected by the patient at least a month previously, and he was worried about them as they did not show any signs of disappearing.

Scrapings from one of the white patches consisted mainly of fungal hyphae in short lengths. They were about 1 μ in diameter, branched, and either Gram-positive or composed of Gram-positive coccoid bodies and rods connected together by Gram-negative strands.

Inoculations made on agar and glucose agar were unsuccessful. Further particulars with regard to the fungus cannot, therefore, be given.

This condition is referred to by Castellani and Chalmers (1919) in their *Manual of Tropical Medicine*. The above case is recorded here merely to draw attention to the fact that it occurs in West Africa.

REFERENCE

CASTELLANI, A., and CHALMERS, A. J. (1919). *Manual of Tropical Medicine*, Third Edition, pp. 1747-8. London: Bailliere, Tindall and Cox.

A FUNGUS OF THE GENUS *NOCARDIA* CULTIVATED FROM HEART BLOOD

BY

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AND

A. INGRAM

(*Received for publication* 24 *August*, 1921)

The fungus here briefly described was cultivated from blood withdrawn from the heart at the autopsy on a patient who died in May, 1920, at Accra, of an obscure complaint. The notes of the case are as follows:—

The deceased was a native man, about twenty-five years of age, regarded clinically as possibly suffering from encephalitis lethargica, and said to have been ill six days before death. He was stated to have shown paretic symptoms of the arms, and to have had convulsive seizures during which there was opisthotonus. Consciousness was lost temporarily during the illness, but was recovered before death.

At the autopsy, which was made on the 14th of May, 1920, eight hours after death, the body was found to be well nourished; post-mortem rigidity was present in the legs and arms but absent from the neck. There was an old scar over the external aspect of the right upper arm immediately above the elbow joint, an old circular cicatrix about the size of a sixpenny piece over the left malar bone, and a small punctured wound at the back of the neck on a line with the thyroid cartilage: the latter wound was oozing blood, and may have been inflicted after death when placing the body in the coffin.

On examining the internal organs, both lungs were found to be affected with broncho-pneumonia: the left lung was adherent to the

parietal wall by recent fibrinous formations. Brain: meninges somewhat congested; blood vessels in sulci engorged; no pus on the surface nor at the base. Heart: blood fluid; no abnormality noted. Cultures were made with blood obtained from the heart by puncturing the organ after searing its surface and taking every precaution to avoid contamination: in these cultures the *Nocardia* was grown. Digestive track, spleen, kidney, and liver: congested, but otherwise showed no apparent pathological condition.

The organism cultivated from the heart blood of this case grew well on blood agar and 'nasgar' at 37° C. and at the temperature of the laboratory, about 26° C., producing a somewhat slowly spreading growth which was very firmly adherent to the medium. The colonies were at first smooth and dome-shaped, but later became puckered and opaque in the middle and radially striated and semi-transparent at the periphery. After a few days an efflorescence appeared on the older parts of the growth which in the earliest cultures was abundant and blue, and in later subcultures was scanty and grey or white. The medium sublying the growth was not stained. The organism grew both aerobically and anaerobically, but slowly and rather feebly under the latter conditions. The cultures had no distinctive odour.

When examined microscopically the growth was seen to be composed of freely branching non-septate hyphae about 1 μ or less in diameter. In old cultures many of the hyphae were more or less fragmented, and the ends of some of the filaments were slightly thickened and club-shaped. The organism was Gram-positive but not acid fast.

It grew well on blood-agar and 'nasgar,' as already stated. When first isolated it grew scantily on agar, but subcultures were not successful. It did not grow on glucose agar or maltose agar. On potato it produced an abundant whiteish growth which developed a brown or grey-brown efflorescence and stained the medium dark brown. On blood serum it grew well, causing no liquefaction but staining the medium dark brown. It did not grow on gelatin, nor in ordinary broth and peptone water.

Its qualitative bio-chemical reactions were tested, and no change was produced in any of the following:—Arabinose, Rhamnose (iso-dulcite), Galactose, Glucose, Laevulose, Mannose, Lactose,

Maltose, Saccharose, Raffinose, Amylum, Dextrin, Glycogen, Inulin, Amygdalin, Helicin, Phlorrhizin, Salicin, Glycerol, Erythrol, Adonitol, Dulcitol, Inosite, Mannitol, Sorbitol, and Litmus milk.

A guinea-pig inoculated intraperitoneally with an emulsion of a culture appeared to be unaffected. This experiment, however, was not made until seven months after the organism was isolated.

The organism showed the characters of a fungus of the Genus *Nocardia*, but so far as we are able to ascertain, does not correspond with any of the numerous species already described. Although it was obtained in cultures made from blood aspirated from the heart, it is not possible to say if the organism is pathogenic to man, but the fact that its growth was almost restricted to potato and media containing either blood serum or ascitic fluid is perhaps significant. We propose for this fungus the name *Nocardia cruoris*.

SUPPLEMENTARY NOTE ON A CASE OF BRONCHOMONILIASIS IN A NATIVE OF THE GOLD COAST

A short time ago (1921) we described a fungus of the Genus *Monilia* which we had isolated from a case of bronchomoniliasis at Accra. The fungus belonged to the *Tropicalis* group of Castellani and Chalmers, and closely resembled in its bio-chemical reactions *M. nivea*, but we could not say at that time whether it was actually the same or distinct, because we were unable to test its action on Raffinose.

We are now able to fill in this gap in our description, and to state that neither acid nor gas is produced in Raffinose. The fungus, at the time this reaction was tested, had been isolated and maintained in cultures in the laboratory for about eight months, but a re-examination of its other bio-chemical reactions showed that they had not appreciably altered. The organism, therefore, cannot be regarded as *M. nivea*, and as previously pointed out, it differs from all the other members of the *Tropicalis* group; it must, therefore, be regarded as a new species, for which we propose the name *Monilia accraensis*.

In support of the view that the failure of the fungus to ferment Raffinose was not due to the loss of this property after isolation from the human host, it may be added that we have recently obtained the same organism from the sputum of another native patient at Accra, and that when tested immediately after isolation it produced neither acid nor gas in this medium.

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REPORT ON RAT-FLEA INVESTIGATION*

BY

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AND

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INTRODUCTION

The investigation was carried out in conjunction with Dr. E. W. Hope, Medical Officer of Health for the City of Liverpool, and his Assistant, Dr. W. Hanna, whose material assistance has made it possible for us to carry it to a successful conclusion.

The object of the investigation was to determine the distribution of the various species of fleas occurring on the rats in the Port and City of Liverpool, with special reference to those species which are responsible for the transmission of plague from rat to rat and from rat to man.

The period during which the investigation was carried out extended from April 12th, 1920, to April 12th, 1921, rats being examined daily five times each week, except during the month of August and from December 22nd, 1920, to January 12th, 1921.

TECHNIQUE

As a preliminary to these investigations, field observations were conducted as to the general methods adopted by the professional rat catchers in the capture of the animals on board ship and in the city.

It was then decided that the rats sent to the laboratory for examination were to be taken alive from the traps, and placed singly in strong calico bags. The bags were subsequently placed in a lethal chamber, where they remained until the rats and the fleas upon them were dead. This method ensured that all the fleas living on each rat at the time of capture were secured. It was further

* Reprinted from *The Annual Report of the Medical Officer of Health (Liverpool) to the Port Sanitary Authority, for the year* 1920, by permission of Prof. E. W. Hope, M.D., with additional charts, etc.

decided that, as far as possible, only rats caught singly in traps were to be sent to the laboratory, because it was seen that, when a number of rats are together in one trap, sweating is apt to occur, with the result that the fleas leave the rats before the latter are captured.

LABORATORY METHODS

The fleas were collected from each bag and rat, over a sheet of white paper, and placed in a numbered watch-glass containing glycerine. In this medium they were arranged in rows on a slide, and identified by microscopical examination.

DEFINITION OF ZONES

ZONE I.—SHIPS. The number of ships from which rats were received was one hundred and twenty-five. The ports from which the ships sailed are named in Table I (*vide infra*).

ZONE II.—DOCKS, ETC. This Zone comprises that part of the Port of Liverpool lying west of a certain line, which defined as accurately as possible the eastward boundary of the warehouse area of the Port.

(*a*) *Docks.* This section of Zone II is limited to the wharves themselves and the sheds actually situated on the Docks.

(*b*) *Warehouses.* This section includes the rest of Zone II; the majority of the buildings, from which rats were received, were warehouses.

ZONE III.—CITY. All of the City east of the line bounding Zone II is included in this Zone.

THE SPECIES OF RATS

No attempt is made to separate the varieties of the species *Mus rattus* and *Mus norvegicus*. *Mus rattus* and its varieties are included under the heading 'black rat,' and *Mus norvegicus* and any varieties are referred to as 'brown rats.'

As will be seen from the following table, all the rats received from ships were black. In Zone IIA the black rats outnumbered the brown

TABLE I.

Showing the number of rats received from ships sailing from the various ports.

Region	Port	No. of rats
Mediterranean	Alexandria	64
	Constantinople	5
	Costanza	2
	Genoa	5
	Salonika	4
		80
India, Ceylon, E. Indies, Burma ...	Bombay*	5
	Calcutta*	18
	Colombo*	4
	Rangoon*	47
	Java*	1
		75
East Africa	Beira*	1
	Mombasa*	3
	Various Ports	1
		5
West Coast of Africa	Various Ports	59
West Coast of S. America	Valparaiso	5
	Callao	13
	Coronel	18
	Pisco*	3
	Talcahuano	3
	Various Ports	33
		75
Brazil	Bahia*	1
	Pernambuco*	18
	Rio de Janeiro*	13
	Rio Grande	5
		37
Argentine	Buenos Aires	53
	R. Plate	17
	Rosario	15
		85
North America	Galveston	14
	New Orleans	40
	New York	1
		55

* Within the Tropics.

rats by nearly five to one. In Zone IIB, the black rats were much more numerous than the brown rats. In Zone III, however, the position is more than reversed, the brown rats being nearly nine times as numerous as the black rats.

TABLE II.

Showing the distribution of black and brown rats.

Zone	Black rats	Brown rats	Total
I	469	—	469
IIA	24	5	29
IIB	442	274	716
III	20	179	199
TOTALS	955	458	1,413

TABLE III.

Showing distribution of the various species of fleas.

Zone	*Xenopsylla cheopis*	*Ceratophyllus fasciatus*	*Ceratophyllus londiniensis*	*Leptopsylla musculi*	*Ctenocephalus Canis*	Totals
I	489	219	—	8	—	706
IIA	10	75	—	9	—	94
IIB	60*	1,510	3	326	—	1,899
III	3	320	12	10	1	346
TOTALS ...	562	2,124	15	353	1	3,045

* This figure includes 56 specimens from No. 32 T—— Street.

OBSERVATIONS ON THE VARIOUS SPECIES OF FLEAS FOUND

Xenopsylla cheopis, Rothsch.

The Indian Plague flea is 'the common rat flea of the tropics' (Rothschild, 1910). It is prevalent also in sub-tropical countries, and 'is common during summer and autumn in some of the warmer parts of the temperate zone, more especially in ports which have maritime intercourse with the tropics' (Chick and Martin, 1911). It has been demonstrated experimentally by Bacot (1914) that temperatures below 40° F. are fatal to all but the imaginal stages

of this species. Its almost complete absence from more northern latitudes is therefore attributed to the low winter temperatures which prevail there. In England, *X. cheopis* has been recorded from a brown rat at Plymouth (one specimen) (Rothschild, 1905); from a plague-infected brown rat at Bristol (two specimens), 1916, taken in a rag factory that was the seat of an outbreak of plague; and in 1911 from Guy's Hospital, London, where the species had established itself on a colony of brown rats. In the last case, it was found that the infested rats were living in an artificially heated environment, beneath the laboratory, and the presence of this, the first flourishing colony of *X. cheopis* to be found in England, was attributed to this fact.

SEASONAL VARIATION (Chart II and Table VII). Zone I is the only Zone from which a sufficient number of specimens of *X. cheopis* have been found to allow of any deductions as to seasonal variation. The curve, Chart II, has no very well marked characteristics; the highest point reached, June, 1920, rises from low figures in both May and July. The months September, October, November, show a second but not so great elevation, falling to the lowest figure in December.

In view of the prophetic statement put forward by Chick and Martin (1911, p. 125), it is interesting to observe that we have found a number of *X. cheopis* on the ship rats during every month in the year, the lowest being 0·30 in December, 1921, and the highest 2·18 in June—not in September, as might have been expected.

Owing to the large numbers of *Xenopsylla cheopis* which occur on ship rats, it would appear likely that this species might be present on some of the rats found in the dock sheds. This was found to be the case; out of the twenty-four rats received from Zone IIA, three were found to carry *X. cheopis*. The data were as follows:—

TABLE IV.

No.	Date	Rat		Building	*X. cheopis*
		Black	Brown		
127	31.v.20	1	—	S. H—— Dock	2
148	7.vi.20	1	—	S. C—— Dock	7
192	23.vi.20	—	1	C—— Dock	1
TOTAL ...		2	1		10

In Zone IIB and Zone III, apart from the colony of *X. cheopis* found in T—— Street, which is dealt with in a separate section, isolated specimens of this species were found in a few cases. The data are as follows:—

TABLE V.

Zone IIB.

No.	Date	Rat		Building	*X. cheopis*
		Black	Brown		
1019	21.i.21	—	1	14 C—— Street	1
1127	10.ii.21	—	1	29 C—— Street	1
1135	11.ii.21	—	1	27 K—— Street	1
1417	12.iv.21	—	1	M—— Mills	1
TOTAL ...		0	4		4

Zone III.

No.	Date	Rat		Building	*X. cheopis*
		Black	Brown		
1068	31.i.21	—	1	5 B—— Road	1
1401	8.iv.21	1	—	W—— Village	2
TOTAL ...		1	1		3

Ceratophyllus fasciatus, Bosc.

This is the common rat flea of temperate countries. In the rural districts of Suffolk and North Essex, Strickland and Merriman (1913) found this species to comprise 60 per cent. of the flea population of rats. Our figures show a much higher percentage of *C. fasciatus* for the city of Liverpool:—78 per cent. in Zone IIB and 92 per cent. in Zone III.

SEASONAL VARIATION (Chart III and Table VII). The curve of frequency for Zone IIB reaches a markedly high level during the summer months, with elevations in May-June and again in

September. A distinct depression occurs in July. The temperature curve (Chart I), on the other hand, is considerably higher in this latter month than in May. In September it is lower than in July. The frequency curve for Zone III is based on a much smaller number of records than that for Zone IIB, but with one exception it possesses the same characteristics as the latter. The exception occurs in January, when it rises to 4·11. This high figure is due to the occurrence of two very heavily infested rats among a total of nine. The average infestation of the other seven rats was only 0·7. It is apparent that there are two periods of maximum prevalence of the species, one in early summer, and a second in September. (The latter may possibly begin during August.) These periods both occur during the warmer half of the year, but the lack of detailed correlation between the frequency and temperature curves makes it clear that in Liverpool the prevailing atmospheric temperature has not such a direct influence on the prevalence of the species, as results obtained elsewhere in this country have suggested.

There is no correlation between the curves of average humidity and frequency of *C. fasciatus*. It must be noted, however, that the former is based on records taken in the open, and that the atmospheric humidity probably differs considerably in the buildings, sewers, etc., frequented by rats.

HOSTS. All the rats from Zone I were black, therefore no comparison between the number of fleas found on the different species of rats can be made for this Zone. In Zone II the infestation of brown rats with *C. fasciatus* was rather heavier than that of the black rats.

Leptopsylla musculi, Dugès

This is a widely distributed species naturally parasitic on mice (*Mus musculus*), but frequently found on rats where the latter inhabit buildings, etc., frequented by mice. This species is a proved potential carrier of plague bacillus, and 'a small percentage' will, according to Bacot (1919), 'bite man under certain conditions.' Strickland and Martin (1913) found it to comprise a very small percentage of the flea fauna of rats in East Suffolk and North Essex, only three specimens being taken in all. Bacot (1919), however, considers that this species may be more prevalent in England than

this figure suggests. As the following figures show, this is the case in the city of Liverpool:—

	per cent. *L. musculi.*
Zone IIA	9·7 per cent. of total.
Zone IIB	17·2 ,, ,,
Zone III	2·8 ,, ,,

SEASONAL VARIATION (Chart IV and Table VII). The curve shows that the species is most prevalent in Zone II during the months of June-September, after which the numbers fall away to almost zero during December-April. This curve agrees largely with that for *C. fasciatus* in Zone IIB, but the rise takes place a month later, and the disappearance during the winter months is more complete. As in the case of *C. fasciatus*, the curve rises to a high level during September in spite of the drop in temperature during this month.

HOSTS. The numbers of *L. musculi* per rat were almost equal on the two species, the averages were:—

Zone II.—	Brown rat ...	Number of fleas per rat	0·41
	Black rat ...	,, ,, ,,	0·48
,, III.—	Brown rat ...	,, ,, ,,	0·05
	Black rat ...	,, ,, ,,	0·05

Ceratophyllus londiniensis, Roths.

This species is said to be 'A rare Mediterranean species, probably introduced by port rats, has occurred in the house mouse (*Mus musculus*), and *possibly* on the brown rat (*Epimys norvegicus*) in London, Dover and Aberdeen.' (Rothschild, 1911.)

Its distribution in Liverpool is interesting; apart from two isolated cases in Zone II, the records, four in all, came from a certain area, where the species appears to have established itself.

Ctenocephalus canis, Curtis

The common dog flea. This species has frequently been recorded from rats, sometimes in large numbers. It was therefore surprising to find only one specimen, which occurred on a brown rat from Zone III.

Ctenopthalmus agyrtes, Heller

Strickland and Merriman, and Nuttall and Strickland, working in rural districts of East Anglia, found this species to comprise a large proportion of the rat fleas in this part of England. Our records, however, show a complete absence of this species. Rothschild (1915) states that this species occurs on the 'brown rat . . . living in the fields, and on the bank vole . . . the common shrew . . . and others.' It is not, therefore, surprising that it is not found on rats in such an urban district as the City of Liverpool. Further, ten other species of Pulicidae, which are recorded by the above-named authors, from rats in East Anglia, and which are naturally parasitic on birds and small wild mammals, are likewise absent from our records.

PERMANENT BREEDING PLACES OF *XENOPSYLLA CHEOPIS*

On the last day of January, 1921, a specimen of *X. cheopis* was found on a brown rat from No. 32, T—— Street. We requested that more rats should be sent from this building, and altogether we received during the first half of February thirteen *brown* rats from which no fewer than fifty-six *X. cheopis* were taken. The records were as follows:—

TABLE VI.

No.	Date	Brown	*X. cheopis*	*C. fasciatus*
1067	31.i.21	1	1	—
1087	3.ii.21	1	5	2
1094	4.ii.21	1	5	7
1095	4.ii.21	1	5	4
1096	4.ii.21	1	9	4
1097	4.ii.21	1	7	2
1103	7.ii.21	1	6	0
1104	7.ii.21	1	2	8
1105	7.ii.21	1	6	4
1106	7.ii.21	1	1	0
1107	7.ii.21	1	3	4
1108	7.ii.21	1	5	2
1133	11.ii.21	1	1	—
TOTAL		13	56	37

Average *X. cheopis* per rat = 4·3.

There can be no doubt that here at T—— Street is a second 'flourishing colony of *X. cheopis* in the British Islands.' As in the case of the first such colony to be discovered (Rothschild, 1911), its existence is probably to be attributed to the fact that its hosts were living in an artificially heated environment.

Beneath the middle of the roadway adjoining the premises T—— Street runs a steam culvert. The excavations, which it was possible to make, revealed that the rat burrows lead in the direction of the culvert. It was, therefore, thought probable, that the nests

TABLE VII.

Showing the average frequency during each month of the common species in the zones in which they occur.

Date	Average Mean Temperature	Average Humidity	ZONE I		ZONE II (*b*)		ZONE III
			Xenopsylla cheopis	*Ceratophyllus fasciatus*	*Ceratophyllus fasciatus*	*Leptopsylla musculi*	*Ceratophyllus fasciatus*
1920—							
April ...	46·3°	73	0·33	1·75	12·66*	0·0	No rats received
May ...	52·9°	74	0·59	0·90	5·38	0·32	,,
June ...	57·8°	73	2·18	0·40	3·28	1·84	3·27
July ...	57·2°	79	0·51	0·16	2·70	0·89	1·07
August ...	56·4°	80	Investigation suspended.				
September	55·5°	81	1·58	0·0	5·17	1·83	2·24
October ...	51·1°	84	1·75	0·22	1·82	0·46	1·09
November...	45·8°	83	1·18	0·37	1·61	0·41	0·68
December	40·5°	86	0·30	0·09	1·29	0·06	0·58
1921—							
January ...	46·0°	84	0·48	0·03	1·19	0·04	4·11*
February ...	41·1°	84	0·93	0·75	1·33	0·04	1·27
March ...	45·5°	79	0·90	0·70	1·08	0·07	1·00
April ...	46·7°	74	1·00	—	0·61	0·09	0·40

* Based on a very small number of records.

of the rats were situated in the near neighbourhood of the steam culvert, and as the temperature of the latter was found on 21.2.21 to be 105° F., the area surrounding it for a considerable distance must be maintained at a temperature higher than the normal. Unfortunately it was impossible to trace the burrows far enough to discern whether the nests were actually within the area influenced by the steam culvert, and, therefore, the suggested explanation of the presence of this colony of *X. cheopis* can only be regarded as an extremely probable one.

SUMMARY

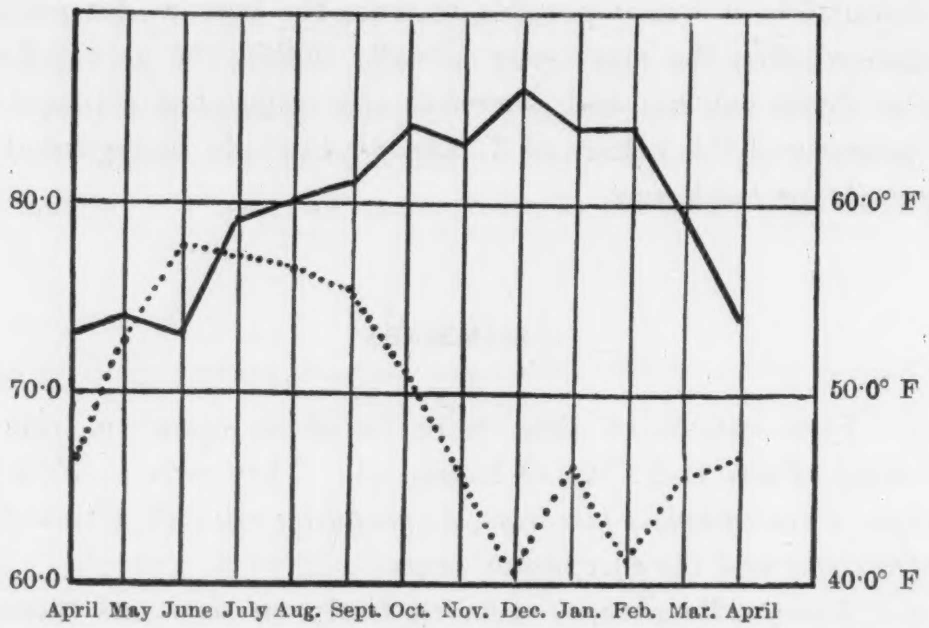
1. Five species of fleas were found to occur on rats from the ships, Port, and City of Liverpool. They were:—*Xenopsylla cheopis, Ceratophyllus fasciatus, Leptopsylla musculi, Ceratophyllus londiniensis*, and *Ctenocephalus canis*.

2. *Xenopsylla cheopis* occurred freely on ship rats throughout the whole period of the investigation. It was also found on three rats from the dock sheds, and isolated specimens were found on four rats from Zone IIB, and on two rats from Zone III. *A permanent breeding place of the species was discovered in certain premises in Zone IIb.*

3. *Ceratophyllus fasciatus* was universally prevalent during the whole course of the investigation. The number of fleas per rat was greatest during the summer months, but the curve of frequency could not be correlated in detail with that of the average temperature.

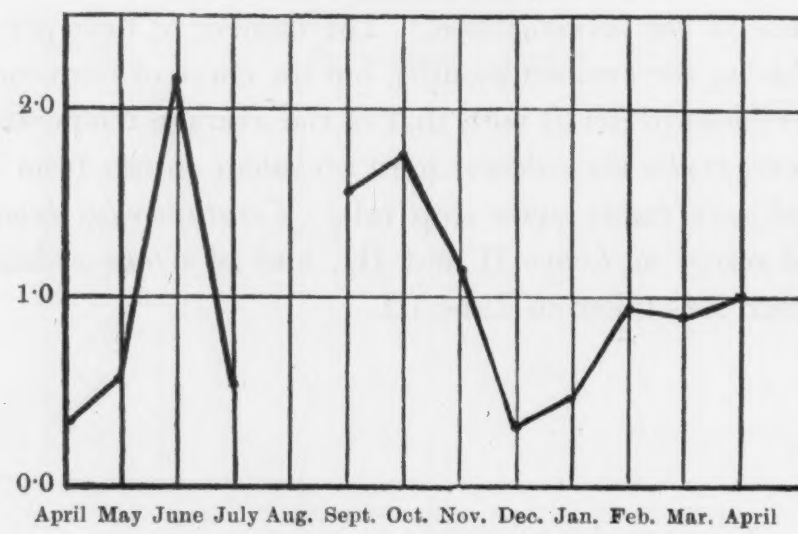
4. *Leptopsylla musculi* was most prevalent on rats from Zone II. It occurred very rarely upon ship rats. *Ceratophyllus londiniensis* was found rarely in Zones II and III, and of *Ctenocephalus canis* one specimen was taken in Zone III.

CHART I



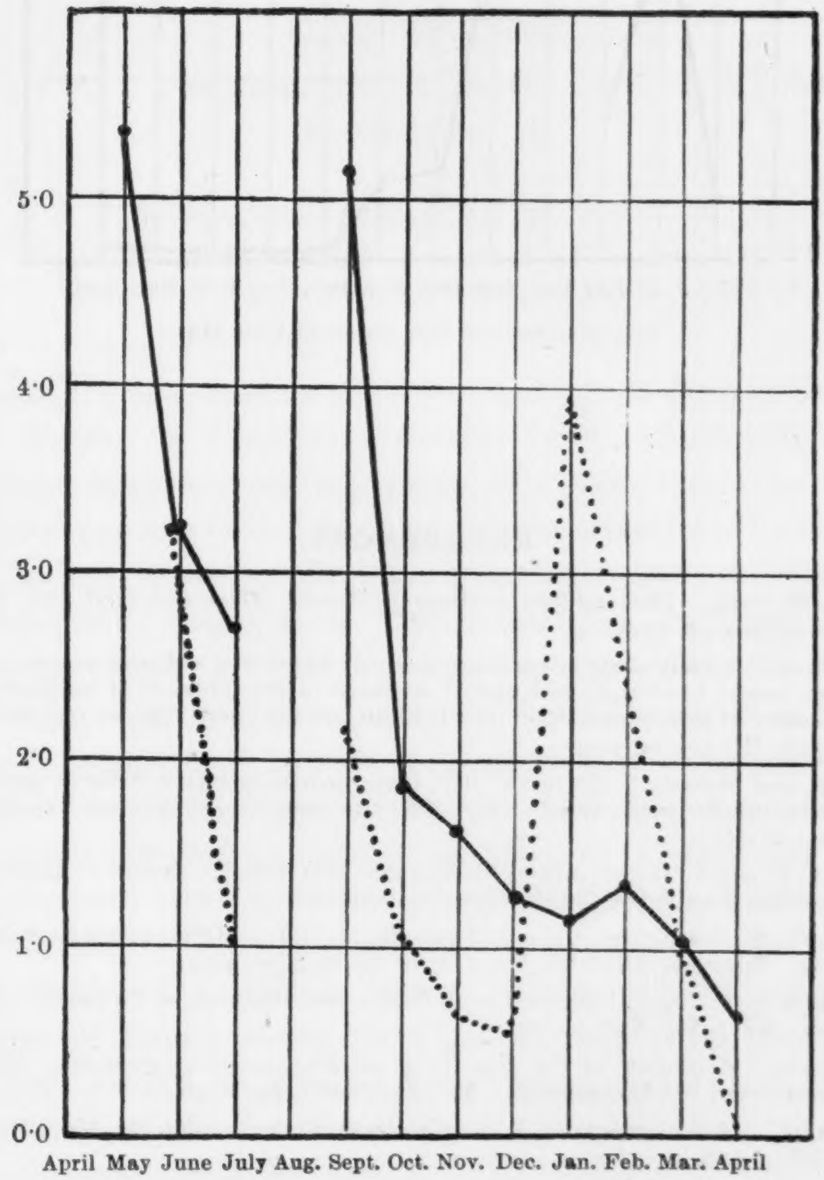
Black line :—Average relative humidity. Dotted line :—Average temperature.

CHART II. *Xenopsylla cheopis*



Average number of fleas per rat in Zone I.

Chart III. *Ceratophyllus fasciatus*



Black line :—Average number of fleas per rat in Zone IIB.

Dotted line :—Average number of fleas per rat in Zone III.

CHART IV. *Leptopsylla musculi*

Average number of fleas per rat in Zone IIB.

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NATURAL ENEMIES OF *STEGOMYIA CALOPUS*, MEIGEN

BY

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(*Received for publication 25 July, 1921*)

PLATES XIX AND XX

During the examination of various collections of water in Manáos for the larvae of *Stegomyia calopus*, their absence from many apparently suitable breeding-places attracted attention. Larvae were found capable of developing in water taken from some of these places, except when certain insects were present. A collection of various aquatic insects from ponds, igarapés, etc., was therefore made and placed in jars of water together with the larvae of *S. calopus*. Under these conditions the following were found to destroy *Stegomyia* larvae with varying degrees of efficiency: larvae of dragonflies, water bugs (*Hemiptera*) and their larvae, larvae of water beetles, and two others not identified. Of these the larvae of dragonflies and water bugs were found to be the most destructive to the larvae of *S. calopus* in captivity.

The habits of *S. calopus* larvae, which constantly range about in search of food, render them particularly liable to attack by predaceous insects, as compared to certain *Culex* and *Anopheles* larvae which may remain stationary at the surface for long periods. The commonest mosquito larvae found in Manáos were those of *Stegomyia calopus* and *Culex fatigans*; these two species were frequently discovered breeding together in wells, barrels and other collections of water. The movements of both larvae and pupae of *C. fatigans* differ from those of *S. calopus* in being much quicker, thus rendering them less easily caught by predaceous insects. The larvae of *C. fatigans* spend most of their time at the surface, but

descend occasionally. On the other hand, the larvae of *S. calopus*, although occasionally searching the surface film for food, while taking in air, spend most of their time ranging over the bottom and sides of their habitat and are thus particularly exposed to attack by the dragonfly larva, which lies in wait at various depths below the surface.

DRAGONFLY LARVAE

Dragonflies are present in Manáos throughout the year, there being no cold season, and larvae were readily found at all times. Although representatives of the AGRIONIDAE have been found in Manáos, members of the AESCHNIDAE and LIBELLULIDAE have been used exclusively in this work. Two species of each of these families are shown (Plate XX, figs. 4 to 7). The larvae of the LIBELLULIDAE (Plate XX, figs. 4 and 5) differ from those of the AESCHNIDAE (Plate XX, figs. 6 and 7) in having the abdomen shorter than the hind legs. According to Miall (1912), the larvae feed on insects, snails, tadpoles, and small fishes. In the laboratory they were observed to attack other aquatic insects, including members of their own species, water bugs and also tadpoles. I have never observed them attempt to seize any object which was not moving. Larvae have been observed resting on plants and on the sides and bottoms of artificial ponds and fountains, igarapés and other natural collections of water. They usually remain motionless and await the approach of suitable prey, which they seize by suddenly shooting out the labium. This is carried on a jointed arm which lies below the head and thorax when not extended. The victim is then broken up rapidly by the jaws and swallowed, only three or four seconds being required for disposal of a *Stegomyia* larva. When the moving object is out of range of the labium they sometimes spring towards it by squirting water from the rectum. When disturbed they also use this method of moving to a greater depth. Respiration is carried out by drawing water into the rectum, but the more fully developed larvae are said to be able to take in air through the thoracic spiracles and, in the case of Aeschnid larvae, directly into the rectum (Miall, 1912).

They are able to live in comparatively foul water. A dragonfly

deposited eggs in a barrel containing thick greenish water with traces of oil on the surface and sides of the barrel and decomposing vegetable matter at the bottom. Larvae of the type shown on Plate XX, fig. 5, developed and lived for at least thirty-nine days, by which time they had reached a size of 2 cms. in length. Observations could not be continued. No dragonfly larvae were found in water which did not receive rain.

One of the dragonfly larvae selected for experiment was identified as *Pantala flavescens*, F., by Dr. G. A. K. Marshall, who describes it as a 'migratory and almost cosmopolitan species.' It was found in several of the artificial ponds and fountains in public squares in Manáos (Plate XIX, figs. 1 and 2), in the igarapés, and by Dr. R. M. Gordon in a broken drainpipe under the pavement of one of the public thoroughfares (Plate XX, fig. 3). In the pond shown (Plate XIX, fig. 1) they were constantly present along with various other species during the period of ten months that they were observed. They destroyed *S. calopus* larvae and pupae of all sizes, usually disposing of the larger ones first.

Six undetermined species of dragonfly larvae were also experimented with, all of which proved destructive to the larvae of *S. calopus*.

WATER BUGS, *HEMIPTERA*

The distribution of the water bugs (*Zaitha* spp.) used in the experiments is somewhat similar to that of the dragonfly larvae, the former having been found occasionally in the pond shown in Plate XIX, fig. 1, and in the igarapés. They are not, however, so plentiful, and difficulty was experienced in obtaining a supply at times. They fed on aquatic and other insects, such as grasshoppers, etc., when placed on the surface of the water, but only when living and showing movement. They also attack their own species. They suck the body juices of their victims, a specimen measuring 1·3 cms. in length taking anything from five to fifteen minutes to dispose of a fully grown *S. calopus* larva. The water bugs are thus considerably slower than the dragonfly larvae, but can continue feeding for a longer period. They usually rest on plants or sides of ponds with the posterior end of the body at the surface, the head downwards

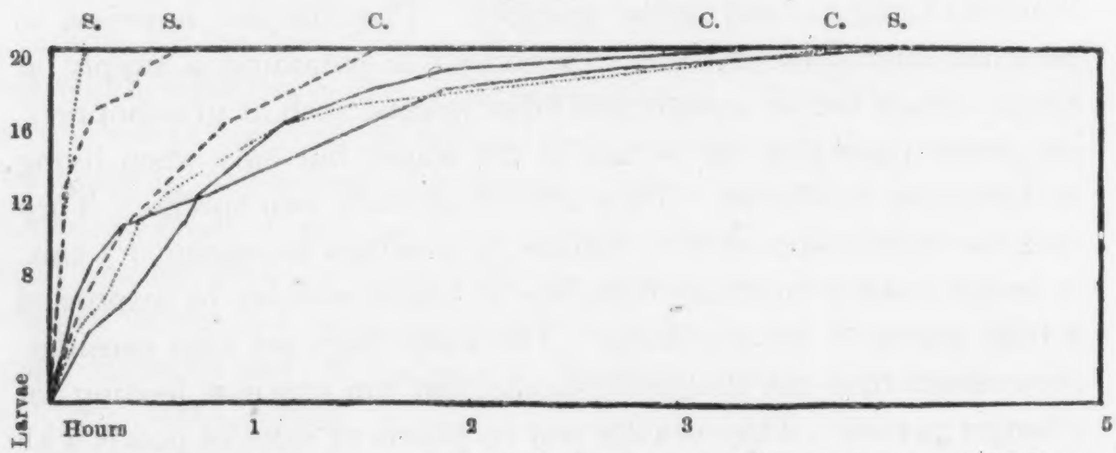
and the front pair of legs hanging free. When a suitable victim approaches it springs on it by a quick movement of the hind legs and seizes it with the fore legs which are adapted for clasping. When the captured insect is large all the legs may be used for gripping, and at least three mosquito larvae can be held at a time. Both adult and larval water bugs fed freely on Culicine larvae.

FEEDING EXPERIMENTS

Experiments were carried out to test the relative efficiency of dragonfly larvae and water bugs under artificial conditions.

Larvae of *P. flavescens*, measuring from 1·4 to 2·1 cms., and water bug larvae of 1·1 to 1·9 cms. in length, were used. Large cylindrical glass jars containing two litres of tapwater were employed, the depth of water in the jar being 10 cms. Twenty fully grown mosquito larvae were used in each experiment and were introduced before the insects to be tested, of which two were always employed. The temperature of the water varied between 28·5° and 32° C. The jar was observed continuously for the first half hour, and at three-quarter, one, one and a quarter, one and a half, two, two and a half, three and five hours, and the number of larvae destroyed during each period recorded. A control jar was used containing twenty mosquito larvae similar to those used in the experimental jar. Control larvae died in one experiment only, and this is not included below. In the graphs shown in text-figs. 1 and 2 the ordinals represent larvae destroyed and the abscissae time in hours. The curves in text-fig. 1 represent the averages of two

FIG. 1.

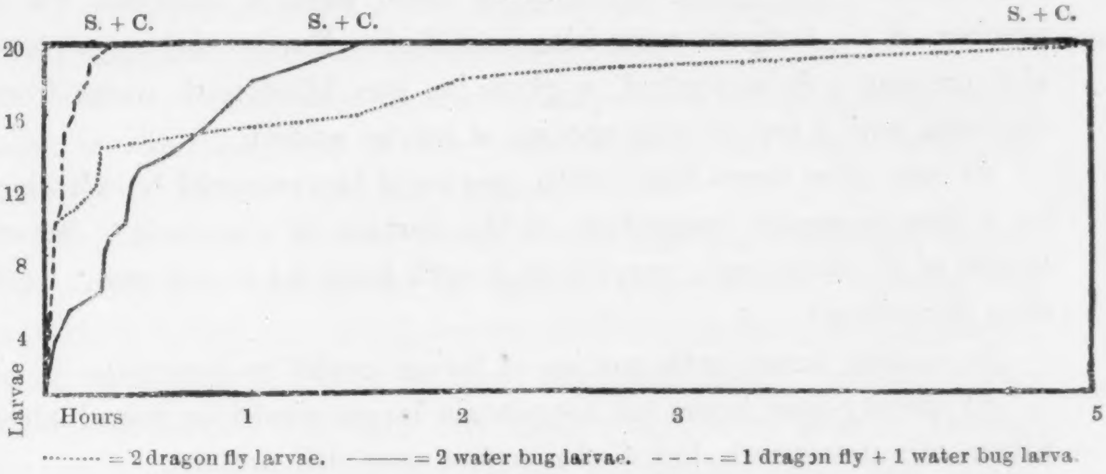


.... = 2 dragon fly larvae. ——— = 2 water bug larvae. - - - - = 1 dragon fly + 1 water bug larva.

S. = 20 larvae of *S. calopus*. C. = 20 larvae of *C. fatigans*.

experiments in each case, but in fig. 2 each curve is constructed from one experiment. It will be observed in text-fig. 1 that fastest time was made by dragonfly larvae with *S. calopus* and second fastest by a combination of dragonfly, water bug and *Stegomyia* larvae. The other curves show only slight differences. In fig. 2 a mixture of

Fig. 2.



S. + C. = { 10 larvae of *S. Calopus.* / 10 larvae of *C. fatigans.* }

equal numbers of *S. calopus* and *C. fatigans* larvae were used, and here a combination of dragonfly with water bug larvae was the most effective. In the dotted curve the two dragonfly larvae destroyed all the *S. calopus* in three minutes, but took five hours to the remaining *Culex* larvae.

So far as rate of destruction was concerned, therefore, under these artificial conditions, dragonfly larvae alone were the most effective with *S. calopus* larvae, and a combination of water bug and dragonfly larvae with those of *C. fatigans.*

As regards quantity, the largest number of fully grown *S. calopus* larvae destroyed by a larva of *P. flavescens* in twenty-four hours was one hundred and fifty-six. This larva during five days, being fed on the first, third and fifth days only, consumed three hundred and seventy-nine larvae. The largest number destroyed by a water bug was one hundred and six in twenty-four hours, but only half of these were killed for feeding purposes; a commoner figure is about sixty. When about to moult these insects cease feeding, so that the numbers consumed in twenty-four hours varied from 0 to the maxima mentioned.

Some experiments with dragonfly larvae were carried out under natural conditions.

An uncovered cement tank, measuring 1 metre square by 78 cms. deep, in a backyard was filled with water to within 10 cms. of the top. Between one thousand one hundred and one thousand two hundred mosquito larvae in all stages of development were introduced. The great majority of these were *S. calopus*, but a number of *C. fatigans* were also included. Pupae and eggs were also present. As a control, a glass jar was filled with water from the tank and a few of both species of larvae added.

At zero (five hours later) both species of larvae could be detected by a few moments inspection of the surface of the tank. Seven larvae of *P. flavescens*, varying in length from 2·3 to 1·3 cms., were then introduced.

At sixteen hours both species of larvae could be detected.

At twenty-four hours no *Stegomyia* larvae could be found after fifteen minutes search, but *Culex* larvae were still present.

At forty hours a few newly hatched *Stegomyia* and three *Culex* larvae only were found. One dragonfly larva was found dead.

At forty-eight hours no larvae of any kind were found.

At fifty hours the tank was emptied by syphoning out the water through several layers of gauze. No mosquito larvae were found.

In the control jar, which had been kept beside the tank throughout the experiment, the larvae remained alive and active. The temperature of the water in the tank varied between 29·5° and 33·5° C.

In the following experiment two barrels kept in an enclosure behind the laboratory were used. Although frequently receiving rain the water in these barrels was somewhat foul, particularly in one which had recently contained oil. In size they measured 85 cms. by 56 cms. at the widest part and the depth of water in each was 65 cms. *Stegomyia calopus* was breeding naturally in both, large numbers of pupae and larvae in all stages of development being present.

At zero (1 p.m.) five larve of *P. flavescens* were introduced into one barrel.

At eighteen hours only small larvae were present.

At twenty-four hours no larvae were found.

During this period larvae and pupae continued to be present in the control barrel to which the five dragonfly larvae were then transferred.

At three hours pupae and larvae were still present.

At seventeen hours only small larvae were present.

At twenty-four hours a few small larvae were present.

At forty-two hours no larvae were found.

Thus two barrels were cleared of *Stegomyia* larvae in twenty-four hours in one case, and in forty-two hours in the other, after the introduction of five dragonfly larvae.

The latter were allowed to remain in the last-mentioned barrel, which contained the larvae of various other insects. During the succeeding twenty-six days, five dragonflies hatched, no *Stegomyia* larvae were observed, but on three occasions newly hatched *Culex* larvae, which did not reach the pupal stage, were found. During the last nineteen days of this period *Stegomyia* and *Culex* larvae were present in the other barrel.

No *Stegomyia* larvae were found in Manáos in any water containing dragonfly larvae.

A certain artificial well which contained dragonfly larvae and was free from mosquito larvae, after being cleaned out was found to be breeding *Culex fatigans* and *Stegomyia calopus*, but no dragonfly larvae were discovered. Five weeks later *Stegomyia* larvae were absent and dragonfly larvae were again found. A few *Culex fatigans* larvae were also present.

THE DRAGONFLY AS AN ENEMY OF THE ADULT MOSQUITO

It was thought probable that the adult dragonfly would prey upon *Stegomyia calopus* if opportunity offered. In fine weather dragonflies are to be seen in the open places and larger streets of Manáos, and particularly around their breeding-places, as well as in the forest. During dull weather they are not so active, resting most of the time on the tops of shrubs and other objects, and rising only in pursuit of insects appearing close at hand.

Both the dragonfly and *Stegomyia calopus* are, therefore, active in Manáos in bright warm weather, but the mosquito is also active at

night. Except for a few attracted into houses by lights, dragonflies were not observed at night.

An attempt was made to see if they pursued *S. calopus* when given the opportunity. It was found possible by moving slowly to approach closely to the resting dragonfly without disturbing it, and *S. calopus* adults were then released from a glass tube at a distance of about a metre from it. The dragonfly nearly always pursued and caught the mosquito, usually returning to its perch consuming it. It was not always possible, owing to the rapidity of its flight, to observe whether the dragonfly actually caught the mosquito, but in most cases it was seen to occur. Five *S. calopus* were released one at a time near a resting dragonfly; four at least were caught, and probably all five. The dragonfly was then caught, and the contents of the alimentary canal teased up in saline and examined microscopically. The mosquitoes were found to be broken up into such small particles as to be unrecognisable, the only indication of *Stegomyia* being the large number of flat scales present.

Five different species of dragonfly, varying in length from 3 cms. to 6 cms., were tried against *S. calopus*, and all pursued and caught the mosquito. The larger ones were also observed to prey upon bluebottles and houseflies.

SUMMARY

Dragonflies and their larvae have been found to be destructive to *Stegomyia calopus* and their larvae respectively. Several other aquatic insects, including water bugs, have also been found to be inimical to *S. calopus* larvae.

My thanks are due to the Director of the Laboratory, Dr. Wolferstan Thomas, for assistance and advice, and to Miss A. M. Evans and Dr. G. A. K. Marshall, Director of the Imperial Bureau of Entomology, for identification of the insects mentioned.

REFERENCE

Miall, L. C. (1912). *The Natural History of Aquatic Insects*, Macmillan & Co.

EXPLANATION OF PLATE XIX

Fig. 1. Gardens in public square in Manáos. Habitat of larvae of *Pantala flavescens*, F., and other dragonflies and water bugs.

Fig. 2. Habitat of larvae of *Pantala flavescens*, F.

Fig. 1

Fig. 2

C. Tinling & Co., Ltd., Imp.

EXPLANATION OF PLATE XX

Fig. 3. Broken drain in street, Manáos. Habitat of larvae of *Pantala flavescens*, F.

Fig. 4. Larva of *Pantala flavescens*. Actual length 1·8 cms.

Fig. 5. Libellulid nymph. Actual length 1·8 cms.

Fig. 6. Aeschnid larva. Actual length 2·1 cms.

Fig. 7. Aeschnid nymph. Actual length 4·7 cms.

FIG. 3

FIG. 5

FIG. 4

FIG. 7

FIG. 6

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WEST AFRICAN CERATOPOGONINAE

BY

A. INGRAM

AND

J. W. S. MACFIE

(*Received for publication* 24 *August*, 1921)

PLATE XXI

This paper is a continuation of the series of papers on the Ceratopogonine Midges of the Gold Coast already published in the *Annals of Tropical Medicine and Parasitology*, and contains descriptions of additional new species. To some extent it is also supplementary, since we are now able to fill in a number of gaps in previous descriptions; for example, particulars are given of the early stages and of the natural habitat of several of the species of *Culicoides* and *Dasyhelea*, facts which are of interest, because they point the way to means of control. It differs from the former papers, however, in that a few species are described which were collected, not in the Gold Coast, but in other parts of British West Africa.

Many of the species belong to genera which were not considered in the previous series; but the number of species referable to each genus is small and insufficient to warrant the inclusion of detailed generic descriptions. For the same reason, keys to the species found in West Africa are not at present necessary. We have found it difficult in some cases to appraise at their proper value the characters employed by Kieffer in separating his smaller genera, and, where we have found only slight divergencies to occur, we have been in doubt whether it would be advisable, as would appear to be strictly necessary, to erect new genera. We regret that in dealing with these species we have not had the advantage of collaboration with Mr. Carter, whose recent appointment as Malariologist in Ceylon has unfortunately made it impossible for us to look to him for the assistance he was ever so ready to give.

Some apology must be made for the figures which compare so unfavourably with those in the previous papers. In the present

paper they are mere outlines traced with the aid of a camera lucida. In figuring the hypopygium of the male we have not often attempted to show it as a whole, but for the sake of clearness and in consideration of our technical shortcomings, have drawn the various organs more or less separated, showing them, unless otherwise indicated, as they appear when seen in a ventral view.

Since our earlier notes on the bionomics of these insects were published (1920) we have located another abundant source of Ceratopogonine midges, namely, the water lettuce *Pistia stratiotes*. This weed, which is exceedingly abundant in rivers, swamps, pools and lagoons in West Africa, and frequently covers large expanses of water, has for many years been recognised as a troublesome mosquito nursery and one very difficult to deal with, not only on account of the association with it of *Mansonioides africanus* but also because it provides protection between its leaves to the larvae of several species of *Anopheles* (*e.g.*, *A. costalis*, *A. mauritianus*, *A. nili*). The very small number of observations which we have made hitherto prove beyond doubt that it is also a fruitful source of midges, for we have reared from it *Culicoides austeni*, *C. distinctipennis*, *Dasyhelea inconspicuosa*, *Prionognathus pseudomaculipennis*, and the species described in the following pages under the names *Kempia ochrosoma*, *Eukraiohelea africana*, *E. versicolor*, *Probezzia pistiae* and *P. stephensi*. Large numbers of *Kempia ochrosoma*, *Eukraiohelea africana* and *Probezzia pistiae* were procured from this source, so that it appears that these species, at any rate, are peculiarly associated with the plant.

The types and co-types of the new species described have been deposited in the museum of the Liverpool School of Tropical Medicine.

Genus *CULICOIDES*, Latr.

Culicoides austeni, Carter, Ingram and Macfie.

Five larvae of this species were found together with numerous larvae of *Ochlerotatus irritans* in a sample of water from a crab-hole. Three of the larvae were reared to the adult stage, the other two were killed and preserved. The larval and pupal pelts of the

specimens reared through to the adult stage were recovered. The following descriptions of the pupa and larva are based on these materials.

PUPA. Length about 2·7 mm. *Respiratory trumpets* short and straight, tapering slightly towards the apex, raised on long stalks; rather strongly chitinised, middle third covered with large squamose spines; length of the trumpet about 0·15 mm., length of the stalk about 0·05 mm. There are no knob-like processes, but the main tracheal trunk gives off in its distal third a continuous row of about nine short blunt processes. *Cephalo-thorax*: anterior marginal tubercle double, highly chitinised, the inner portion large, conical, and bearing a long strong bristle, the outer portion small, unarmed; anterior dorsal very large, highly chitinised, irregularly conical, bearing two stout bristles; dorso-lateral smaller, bearing a long and a short hair; ventro-lateral an irregularly shaped tubercle bearing a long and a short hair and an apparently unarmed socket; ventro-median represented by a moderately long and a very minute hair. External to the ventro-median tubercle and a little posterior to the ventro-lateral is a small, unarmed, nipple-like tubercle which projects prominently outwards. Dorsal tubercles small: anterior single, bearing a minute blunt spine; posterior and lateral each bearing a hair. Immediately in front of, and slightly external to, the the anterior tubercle is a small tubercle which is apparently unarmed; immediately behind, and slightly internal to the posterior, is a small tubercle bearing a very minute spine. Postero-dorsal tubercle small, bearing a hair, and behind it two unarmed sockets. *Abdomen* of the usual form. Anal segment terminating in two sharply pointed, divergent processes which are very highly chitinised, especially at their tips. Tubercles on the abdominal segments small, strongly chitinised; arrangement and armature as in *C. accraensis*.

LARVA. Length about 5·7 mm., greatest breadth about 0·3 mm. *Head*: length about 0·2 mm., greatest breadth about 0·14 mm. Eyes large, bilobed. Bristles small, apparently arranged as in *C. accraensis*. Mental plate with a large, pointed central tooth. Hypopharyngeal sclerite moderately chitinised, bearing on each side usually eleven pointed, finger-like processes which are nearly equal in size, excepting the fifth from the inner margin, which is slightly larger than the others. Mandibles well chitinised, pointed, with a

well-developed central tooth. *Body*: hairs minute, terminal hairs on the anal segment small; anal gills of the usual form.

GOLD COAST: Accra, April, 1921, reared from mud from pools and puddles near the station for the Weshiang Line (Pl. XXI, fig. 2); June, 1921, larvae found in water from a crab-hole. Christiansborg, July, 1921, reared from plants of the water weed *Pistia stratiotes*. Oblogo, June, 1921, reared from banana fibre.

Culicoides distinctipennis, Aust.

Although numerous specimens of this species have been collected at Accra, it is only recently that we have reared it from the early stages. In the samples from which it was reared were also the early stages of several other species of *Culicoides*, and we were unable to identify with certainty the larvae. The pupa was, however, obtained, and is briefly described here.

PUPA. Description based on a single pelt from which a male had emerged. Length 1·7 mm. *Respiratory trumpets*, raised on moderately long stalks; length of the trumpet about 0·2 mm., length of the stalk about 0·04 mm. Distal extremity somewhat darkened, middle portion covered with squamose spines, proximal two-thirds bearing three small knob-like processes. Main tracheal trunk terminating distally in a fan-like arrangement of seven short, blunt processes. *Cephalo-thorax* dark, operculum rather sparsely clothed with large, dark, squamose spines. Anterior marginal tubercle small, bearing a rather short, stout spine; anterior dorsal bearing a short, stout spine and a minute spine; dorso-lateral, small, bearing a hair and a short spine; ventro-lateral, small, bearing two hairs, one of which is quite short and spine-like; ventro-median represented by a moderately long and a very small hair. Dorsal tubercles: anterior double, the two halves separated, the one situated anterior and slightly external to the other, each bearing a short, stout, dark-coloured spine; posterior, small and flat, bearing a minute spine; lateral, small, bearing a hair. Posterior to the lateral of the dorsal tubercles is an unarmed socket, and on the dorsum are several ill-defined darkened patches resembling flat, unarmed tubercles. Postero-dorsal tubercle small, bearing a hair and an unarmed socket. *Abdomen* of the usual form. Anal segment terminating

in two sharply pointed, somewhat divergent, dark-tipped processes which are not closely covered by squamose spines. Dorsal, ventro-lateral, and ventral tubercles as in *C. accraensis*.

GOLD COAST: Accra, February to April, 1921; numerous specimens reared from moist soil and mud taken from the margins of pools and puddles near to the railway station on the Weshiang Line (Plate XXI, fig. 2). Oblogo, March, 1921; reared from plants of *Pistia stratiotes* taken from the river Densu (Plate XXI, fig. 1).

Culicoides eriodendroni, C., I. and M.

In a previous paper a description was given of the female of this species. We are now in a position to add certain points in regard to the male.

MEASUREMENTS (average of two).

Length of body*	1·3 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·3 mm.

In general, the description of the female applies also to the male, but the following points may be especially mentioned. Eyes separated. Antenna: last three flagellum segments sub-equal, the fifteenth being, however, slightly the longest and the fourteenth slightly the shortest. Scutellum bearing two central and two lateral bristles, and a few (six) short hairs. Wing: pale spot covering the anterior cross-vein rather diffuse and spreading almost to the costa, pale spots at the apex of the wing and along its posterior border almost or entirely absent; decumbent hairs scanty, but more than a single row in the basal portion of the wing between the fourth and fifth veins.

HYPOPYGIUM (fig. 1). *Ninth segment*: tergite, posterior margin slightly notched in the middle and ending on each side in a well-developed conical process; sternite, deeply excavated. *Forceps*: side-pieces rather long and narrow, covered with relatively short hairs; claspers with a broad, hairy, basal portion, constricting abruptly to meet the terminal portion, which is of the usual form. *Harpes* (fig. 1 *a*): moderately chitinised, somewhat strap-like,

* In all cases taken from the anterior margin of the thorax to the tip of the abdomen of specimens mounted in carbolic.

tapering only slightly, with a short piece at the distal end bent ventrally or ventro-laterally like the end of a cleek. *Aedoeagus* (fig. 1 *b*): form rather unusual; stem very short, highly chitinised, in ventral view shaped like the letter T; limbs long, moderately highly chitinised; ventral wall chitinised for only a short distance from the apex of the arch, membranous portion not spiculated.

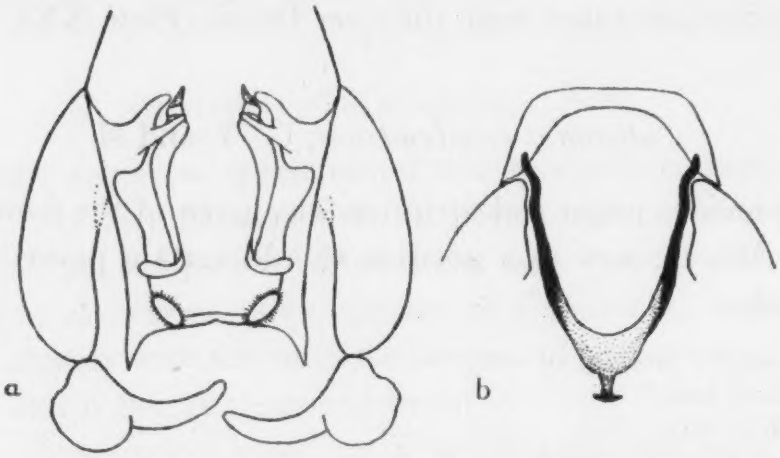

FIG. 1. *Culicoides eriodendroni*, C. I. & M., outlines of male hypopygium, ventral view. *a*—forceps and harpes; *b*—aedoeagus.

GOLD COAST: Nsawam, August and October, 1920; reared from larvae obtained from rot-holes in the stump of a silk-cotton tree and of another tree.

Culicoides grahami, Aust.

Several specimens of this species were reared from material taken from the base of a banana stump. The pupal pelt of one female was recovered, and as it was in some respects peculiar and showed several characteristic features, a brief description of it is given.

PUPA. Length 1·6 mm., moderately well chitinised. *Respiratory trumpets* long and curved; length about 0·17 mm. Stalk or pedicle moderately long. The trumpets are of almost uniform width throughout their length, and are irregularly ringed. The main tracheal trunk gives off during its course through the trumpet a few short lateral branches which terminate in small tubercles scarcely projecting above the general surface level, and ends distally in a fan-like arrangement of the usual form. *Cephalo-thorax*:

anterior marginal tubercle large, covered with squamose spines, bilobed, and formed of an inner rounded portion and an outer conical portion, the latter bearing at its apex a long, strong bristle; anterior dorsal, double, each part bearing a long, stout bristle; anterior dorso-lateral, an irregular tubercle bearing two hairs; ventro-lateral, an irregular tubercle bearing two delicate hairs, ventro-median, apparently absent. The operculum is sparsely covered with squamose spines, most strongly developed along its periphery; near its posterior margin, in the middle line, is a small elevation or tubercle covered with rather coarse squamose spines, but otherwise unarmed. Dorsal tubercles small: anterior, double, bearing a delicate hair internally and a small spine externally; posterior, almost obsolete, bearing a small spine; lateral, bearing a hair. Postero-dorsal tubercle almost obsolete, bearing a delicate hair. *Abdomen*: anal segment bearing two transverse rows of relatively large spicules, the one near the anterior margin and the other about the middle of the segment; these spicules are developed most highly on the dorsal and lateral aspects. A group of similar spicules is present dorsally at the roots of the terminal processes. The terminal processes are short and pointed at their tips, they diverge almost at right angles, and their ends are turned dorsally. Tubercles on the abdominal segments poorly developed, and shaped like large spines. Dorsal tubercles: antero-submarginal, the inner bearing a short spine and the outer a longer hair; postero-marginal, only a single tubercle present, situated posterior to the outer antero-submarginal tubercle, bearing a short spine. Ventro-lateral tubercles small, but little larger than the dorsal and ventral: antero-submarginal bearing a short spine; postero-marginal, the middle one bearing a hair, the other two short spines. Ventral tubercles: the middle one bearing a hair, the outer and inner each a short spine. Each abdominal segment (excluding the last, which has been referred to already) bears a transverse row of relatively well-developed spicules near its anterior margin; these spicules are most highly developed and most numerous on the more posterior segments.

GOLD COAST: Nsawam, 24th July, 1920; reared from material taken from the base of a banana stump.

Culicoides neavei, Aust.

Several specimens of this species were reared from soft mud taken from the edges of pools at Accra. The larvae, together with those of several other species of *Culicoides*, frequented the mud which was very soft and almost semi-fluid. They were of the usual form, but we are unable to give details of their structure because, although we reared one adult from a larva isolated in a small tube, we did not succeed in recovering the larval pelt, and were, therefore, unable to distinguish amongst the numerous larvae in the sample those belonging to this particular species. The pupae also frequented the mud: the description which follows is based on an examination of the pelts of two pupae which had been isolated singly, and from which adult insects were procured.

PUPA. Length about 1·9 mm. Operculum densely covered with dark brown squamose spines. *Respiratory trumpets* similar to those of *Culicoides inornatipennis*, short and raised on relatively long stalks; length of the trumpet about 0·19 mm., length of the stalk about 0·05 mm. The trumpet is infuscated at its distal end, and also, slightly, at its base; it bears three or four quite small knob-like processes, the most distal of which is situated rather far anteriorly. The main tracheal trunk terminates distally in a hand-like group of about six short blunt processes. *Cephalo-thorax*: anterior marginal tubercle small, dark coloured, conical, bearing a relatively long stout spine which is directed ventrally, anterior dorsal well developed, conical, bearing a short stout spine and a minute spine; dorso-lateral prominent, bearing a hair and a short spine; ventro-lateral a rounded hump, bearing a short and a moderately long hair; ventro-median small, bearing a moderately long and a short hair. External to the ventro-median tubercle, and a little posterior to the ventro-lateral, is a small nipple-like tubercle, apparently unarmed. Just in front of and internal to the base of the stalk of the trumpet is a small hair. Dorsal tubercles: anterior double, the two parts being separate and well developed but not large knobs, the one situated anterior to the other, each bearing a short, stout, dark-coloured spine; posterior, poorly developed, bearing a minute spine; lateral, feebly developed, bearing a hair. In front of the anterior tubercle, and a little external to it, is an inconspicuous unarmed tubercle; posterior to the lateral tubercle is a socket-like

mark, apparently unarmed, and there is another similar mark situated more posteriorly. Postero-dorsal tubercle small, bearing a hair and two apparently unarmed, socket-like marks. *Abdomen*: anal segment with sharply-pointed terminal processes infuscated at their tips. Dorsal tubercles of the normal form: antero-submarginal, the inner bearing a short spine, and the outer a hair; postero-marginal, five in number, the outermost bearing a hair, the next a short spine, the innermost a minute spine, and the other two apparently unarmed. Lateral tubercles larger than the others and each with two sharp points, between which are the hairs or spines: antero-submarginal, bearing a spine; postero-marginal, the middle one bearing a hair, the other two, spines. Traces are visible of a second, rudimentary, antero-submarginal tubercle in a more dorso-lateral position. Ventral tubercles of normal form: the middle one bearing a hair, the other two, spines.

GOLD COAST: Accra, February, 1921; reared from soft mud taken from the edges of pools and puddles near the station for the Weshiang railway (Pl. XXI, fig. 2). From the same material were reared also *Culicoides austeni*, *C. distinctipennis*, *C. similis*, *C. schultzei* and *Stilobezzia spirogyrae*.

Culicoides similis, C., I. and M.

At the time when this species was described (1920), the early stages were not known. They have since been collected, and are here briefly described.

PUPA. Length about 1·9 mm. Operculum densely covered with dark brown squamose spines. *Respiratory trumpets* short and raised on rather long stalks; length of the trumpet about 0·19 mm., length of the stalk about 0·03 mm. The trumpet bears on its proximal half three or four small knob-like processes which are infuscated. The distal end of the trumpet is dark brown: in it the main tracheal trunk terminates in a fan-like group of short, blunt processes. *Cephalo-thorax*: anterior marginal tubercle dark brown, rather small, conical, bearing a relatively long, stout, dark-coloured spine; anterior dorsal prominent, irregularly conical, bearing a stout spine and a minute spine; dorso-lateral small, bearing a hair and a minute spine; ventro-lateral a rounded hump, bearing a small and a minute hair; ventro-median represented by two hairs,

Culicoides neavei, Aust.

Several specimens of this species were reared from soft mud taken from the edges of pools at Accra. The larvae, together with those of several other species of *Culicoides*, frequented the mud which was very soft and almost semi-fluid. They were of the usual form, but we are unable to give details of their structure because, although we reared one adult from a larva isolated in a small tube, we did not succeed in recovering the larval pelt, and were, therefore, unable to distinguish amongst the numerous larvae in the sample those belonging to this particular species. The pupae also frequented the mud: the description which follows is based on an examination of the pelts of two pupae which had been isolated singly, and from which adult insects were procured.

PUPA. Length about 1·9 mm. Operculum densely covered with dark brown squamose spines. *Respiratory trumpets* similar to those of *Culicoides inornatipennis*, short and raised on relatively long stalks; length of the trumpet about 0·19 mm., length of the stalk about 0·05 mm. The trumpet is infuscated at its distal end, and also, slightly, at its base; it bears three or four quite small knob-like processes, the most distal of which is situated rather far anteriorly. The main tracheal trunk terminates distally in a hand-like group of about six short blunt processes. *Cephalo-thorax*: anterior marginal tubercle small, dark coloured, conical, bearing a relatively long stout spine which is directed ventrally, anterior dorsal well developed, conical, bearing a short stout spine and a minute spine; dorso-lateral prominent, bearing a hair and a short spine; ventro-lateral a rounded hump, bearing a short and a moderately long hair; ventro-median small, bearing a moderately long and a short hair. External to the ventro-median tubercle, and a little posterior to the ventro-lateral, is a small nipple-like tubercle, apparently unarmed. Just in front of and internal to the base of the stalk of the trumpet is a small hair. Dorsal tubercles: anterior double, the two parts being separate and well developed but not large knobs, the one situated anterior to the other, each bearing a short, stout, dark-coloured spine; posterior, poorly developed, bearing a minute spine; lateral, feebly developed, bearing a hair. In front of the anterior tubercle, and a little external to it, is an inconspicuous unarmed tubercle; posterior to the lateral tubercle is a socket-like

mark, apparently unarmed, and there is another similar mark situated more posteriorly. Postero-dorsal tubercle small, bearing a hair and two apparently unarmed, socket-like marks. *Abdomen*: anal segment with sharply-pointed terminal processes infuscated at their tips. Dorsal tubercles of the normal form: antero-submarginal, the inner bearing a short spine, and the outer a hair; postero-marginal, five in number, the outermost bearing a hair, the next a short spine, the innermost a minute spine, and the other two apparently unarmed. Lateral tubercles larger than the others and each with two sharp points, between which are the hairs or spines: antero-submarginal, bearing a spine; postero-marginal, the middle one bearing a hair, the other two, spines. Traces are visible of a second, rudimentary, antero-submarginal tubercle in a more dorso-lateral position. Ventral tubercles of normal form: the middle one bearing a hair, the other two, spines.

GOLD COAST: Accra, February, 1921; reared from soft mud taken from the edges of pools and puddles near the station for the Weshiang railway (Pl. XXI, fig. 2). From the same material were reared also *Culicoides austeni*, *C. distinctipennis*, *C. similis*, *C. schultzei* and *Stilobezzia spirogyrae*.

Culicoides similis, C., I. and M.

At the time when this species was described (1920), the early stages were not known. They have since been collected, and are here briefly described.

PUPA. Length about 1·9 mm. Operculum densely covered with dark brown squamose spines. *Respiratory trumpets* short and raised on rather long stalks; length of the trumpet about 0·19 mm., length of the stalk about 0·03 mm. The trumpet bears on its proximal half three or four small knob-like processes which are infuscated. The distal end of the trumpet is dark brown: in it the main tracheal trunk terminates in a fan-like group of short, blunt processes. *Cephalo-thorax*: anterior marginal tubercle dark brown, rather small, conical, bearing a relatively long, stout, dark-coloured spine; anterior dorsal prominent, irregularly conical, bearing a stout spine and a minute spine; dorso-lateral small, bearing a hair and a minute spine; ventro-lateral a rounded hump, bearing a small and a minute hair; ventro-median represented by two hairs,

one minute. Dorsal tubercles: anterior usually double (in one specimen single on one side), the two parts contiguous or separated but almost side by side, well developed but not large knobs, each bearing a short, stout, dark-coloured spine; posterior, poorly developed, bearing a minute spine; lateral, poorly developed, bearing a hair. In front of the anterior tubercle, and a little external to it, is an unarmed tubercle; posterior to the lateral tubercle is a socket-like mark, apparently unarmed, and there are usually two similar marks situated more posteriorly. Postero-dorsal tubercle small, bearing a small hair and one or two apparently unarmed, socket-like marks. *Abdomen*: anal segment with sharply-pointed terminal processes infuscated at their tips; in the middle line, dorsally and posteriorly, is a small elevation covered with dark squamose spines. Dorsal tubercles of the normal form usually, but on some segments the outer two postero-marginal tubercles tend towards the form of the lateral tubercles: antero-submarginal, the inner bearing a short spine, and the outer a hair; postero-marginal, five in number, the outermost bearing a hair, the next a spine, the innermost a minute spine, and the other two apparently unarmed. Lateral tubercles larger than the others, and each with two sharp points between which arises the hair or spine: antero-submarginal, bearing a spine; postero-marginal, the middle one bearing a hair, the other two, spines. Traces are visible of a second, rudimentary, antero-submarginal tubercle in a more dorso-lateral position. Ventral tubercles of normal form: the middle one bearing a hair, the other two, spines.

LARVA. Although we did not succeed in recovering the larval pelt of any individual specimen isolated and reared through from the larval stage, we secured from the materials collected at Accra a number of larvae which we believe to be those of *Culicoides similis*. The larvae were found, together with pupae of *C. similis*, in the soft, semi-fluid mud in the specimen jar at a time when this species was the only one emerging from the sample. Moreover, in three of the larvae, apparently almost ready to pupate, the pupal structures, including the respiratory trumpets and many of the cephalo-thoracic and abdominal tubercles, were clearly visible through the cuticle, and appeared to be identical with those of the pupa of *C. similis*.

It is of interest to note the situations in which certain of the pupal structures were seen in the larvae. The trumpets lay in the first body segment, their proximal ends situated dorsally and laterally at the posterior end of the segment, and their free ends situated ventrally on each side of the middle line a little posterior to the head. The dorsal tubercles of the cephalo-thorax were situated dorsally at the anterior end of the second body segment. The terminal processes of the anal segment were turned so that they projected anteriorly, one on each side, with their tips directed dorsally and situated at the anterior margin of the segment.

The following description of the larva is based on the examination of the three larvae alluded to as being apparently ready to pupate.

Length about 3·5 mm. when fully grown, greatest breadth about 0·02 mm. *Head*, length about 0·13 mm., greatest breadth about 0·08 mm. Eyes small. Bristles mostly small; on the ventral surface one pair, admedian, a little posterior to the hypopharyngeal sclerite, two pairs, admedian, almost contiguous, anterior to the hypopharyngeal sclerite, and one pair ventro-lateral; on the lateral surface two pairs, the one anterior and the other central; on the dorsal surface one pair admedian, anterior, two pairs sub-central, slightly separated, dorso-sublateral, two pairs, almost contiguous, posterior, dorso-lateral. Palpi and antennae well developed. Labium broad, blunt, dark coloured, apparently without teeth. Posterior margin of hypopharyngeal sclerite bearing on each side seven or eight sharply pointed, graded, teeth, the middle ones being the longest; these teeth are not very highly chitinised. Mandibles simple, pointed, without teeth. *Body*: appearing almost hairless, but actually bearing a few very small hairs; terminal hairs on the anal segment very small; anal gills of the usual form, deeply cleft distally into two pointed processes.

GOLD COAST: Accra, February to April, 1921; numerous specimens of both sexes reared from soft mud taken from the edges of pools and puddles near the station for the Weshiang railway (Pl. XXI, fig. 2). Oblogo, February, 1921; a few specimens reared from sandy mud taken from the washing-place in the river Densu.

Culicoides corsoni, sp.n.

This insect, of which we possess at present only a single male, resembles in wing markings *Culicoides similis* and *C. citroneus*. From the former it differs in having no pale area covering the middle of the lower ramus of the fourth vein and in the whole of the cross-vein being enveloped in a pale area; from the latter in having only a single pale area between the branches of the fifth vein, the small pale spot in the angle being absent.

MEASUREMENTS.

Length of body (one male)	1·0 mm.
Length of wing	0·8 mm.
Greatest breadth of wing	0·3 mm.

Head: occiput dark brown. Eyes narrowly separated. Proboscis and palpi dark brown; the latter with the third segment somewhat inflated, especially in its basal two-thirds. *Antennae*: infuscated; the thirteenth segment slightly longer than the terminal segment; the plumes only moderately developed. *Thorax* dark brown, with paler brown markings. Owing to the fact that the species was not recognised until the hypopygium had been examined in carbolic, exact details of the thoracic adornment cannot be given, but there appeared to be three large paler areas on each side of the anterior two-thirds of the dorsum, one in front and two behind. Scutellum yellowish-brown, somewhat darker at the sides; bearing one central and two lateral bristles, and a few (three) short hairs. Post-scutellum dark brown. Pleurae dark brown. *Wings* with pale markings resembling those of *Culicoides citroneus*. The pale spot in the middle of the anterior border covers the tip of the distal cell; there is no pale spot covering the middle of the lower ramus of the fourth vein, and the pale spots in the neighbourhood of the bifurcation of the fifth vein are arranged as in *C. similis*. Decumbent hairs scanty, not extending beyond the middle of the wing, and none being present in the anal angle, between the rami of the fifth vein, or at the base between the fourth and fifth veins. Halteres with creamy-yellow knobs. *Legs* infuscated, knees scarcely darker; tibiae with narrow pale bands basally and less distinct pale bands on the femora apically. *Abdomen* dark brown.

HYPOPYGIUM. *Ninth segment:* tergite broad, bearing only a few stout hairs, the most notable of which are four arranged in a

transverse row near the posterior margin; posterior margin notched in the middle, and bearing at each lateral angle a long, slender, finger-like process about five times as long as it is broad at its base; apical lobe-like processes well developed. Sternite deeply excavated centrally. *Forceps* of the normal form; claspers highly chitinised, with rather blunt ends. *Harpes* resembling those of *C. grahami*, but with shorter distal portions. *Aedoeagus* Y-shaped, the limbs and the proximal end of the stem highly chitinised, the distal end of the stem more delicate and ending in a broad lip. The ventral wall of the aedoeagus is highly chitinised from the apex of the arch to about the middle of the limbs, but is not extended anteriorly and centrally as a spine; the membrane joining the aedoeagus to the ninth sternite is without spicules. The hypopygium resembles that of *C. citroneus*, but the following differences, amongst others, may be noted. The long hairs at the posterior end of the ninth tergite are less numerous than in *C. citroneus*, the lateral finger-like processes more slender, and more pointed; the claspers are more highly chitinised; the harpes resemble more closely those of *C. grahami* than those of *C. citroneus*; and the proximal ends of the limbs of the aedoeagus are inverted.

GOLD COAST: Koforidua, April, 1921 (Dr. J. F. Corson); one male taken in a bungalow, on the wall near a lamp. We have pleasure in dedicating this species to the collector, Dr. J. F. Corson.

Culicoides nigeriae, sp. n.

MEASUREMENTS.

Length of body (three females)	1·2 mm.
Length of wing	0·9 mm.
Greatest breadth of wing	0·4 mm.

Head dark brown. Eyes separated, internal chitinous thickening well developed; the eyes are more widely separated than in *C. inornatipennis*, the length of the internal chitinous thickening being about 20μ instead of about 13μ. Proboscis dark brown. Palpi brown, third segment moderately inflated. *Antenna* dark brown; segments four to ten from once to once and a half as long as broad. *Thorax* uniformly dark brown, pollinose, sparsely clothed with dark brown hairs. Scutellum uniformly dark brown; bearing two admedian and two lateral bristles, and a few short hairs. Post-

Culicoides corsoni, sp.n.

This insect, of which we possess at present only a single male, resembles in wing markings *Culicoides similis* and *C. citroneus*. From the former it differs in having no pale area covering the middle of the lower ramus of the fourth vein and in the whole of the cross-vein being enveloped in a pale area; from the latter in having only a single pale area between the branches of the fifth vein, the small pale spot in the angle being absent.

MEASUREMENTS.

Length of body (one male)	1·0 mm.
Length of wing	0·8 mm.
Greatest breadth of wing	0·3 mm.

Head: occiput dark brown. Eyes narrowly separated. Proboscis and palpi dark brown; the latter with the third segment somewhat inflated, especially in its basal two-thirds. *Antennae*: infuscated; the thirteenth segment slightly longer than the terminal segment; the plumes only moderately developed. *Thorax* dark brown, with paler brown markings. Owing to the fact that the species was not recognised until the hypopygium had been examined in carbolic, exact details of the thoracic adornment cannot be given, but there appeared to be three large paler areas on each side of the anterior two-thirds of the dorsum, one in front and two behind. Scutellum yellowish-brown, somewhat darker at the sides; bearing one central and two lateral bristles, and a few (three) short hairs. Post-scutellum dark brown. Pleurae dark brown. *Wings* with pale markings resembling those of *Culicoides citroneus*. The pale spot in the middle of the anterior border covers the tip of the distal cell; there is no pale spot covering the middle of the lower ramus of the fourth vein, and the pale spots in the neighbourhood of the bifurcation of the fifth vein are arranged as in *C. similis*. Decumbent hairs scanty, not extending beyond the middle of the wing, and none being present in the anal angle, between the rami of the fifth vein, or at the base between the fourth and fifth veins. Halteres with creamy-yellow knobs. *Legs* infuscated, knees scarcely darker; tibiae with narrow pale bands basally and less distinct pale bands on the femora apically. *Abdomen* dark brown.

HYPOPYGIUM. *Ninth segment:* tergite broad, bearing only a few stout hairs, the most notable of which are four arranged in a

transverse row near the posterior margin; posterior margin notched in the middle, and bearing at each lateral angle a long, slender, finger-like process about five times as long as it is broad at its base; apical lobe-like processes well developed. Sternite deeply excavated centrally. *Forceps* of the normal form; claspers highly chitinised, with rather blunt ends. *Harpes* resembling those of *C. grahami*, but with shorter distal portions. *Aedoeagus* Y-shaped, the limbs and the proximal end of the stem highly chitinised, the distal end of the stem more delicate and ending in a broad lip. The ventral wall of the aedoeagus is highly chitinised from the apex of the arch to about the middle of the limbs, but is not extended anteriorly and centrally as a spine; the membrane joining the aedoeagus to the ninth sternite is without spicules. The hypopygium resembles that of *C. citroneus*, but the following differences, amongst others, may be noted. The long hairs at the posterior end of the ninth tergite are less numerous than in *C. citroneus*, the lateral finger-like processes more slender, and more pointed; the claspers are more highly chitinised; the harpes resemble more closely those of *C. grahami* than those of *C. citroneus*; and the proximal ends of the limbs of the aedoeagus are inverted.

GOLD COAST: Koforidua, April, 1921 (Dr. J. F. Corson); one male taken in a bungalow, on the wall near a lamp. We have pleasure in dedicating this species to the collector, Dr. J. F. Corson.

Culicoides nigeriae, sp. n.

MEASUREMENTS.

Length of body (three females)	1·2 mm.
Length of wing	0·9 mm.
Greatest breadth of wing	0·4 mm.

Head dark brown. Eyes separated, internal chitinous thickening well developed; the eyes are more widely separated than in *C. inornatipennis*, the length of the internal chitinous thickening being about 20μ instead of about 13μ. Proboscis dark brown. Palpi brown, third segment moderately inflated. *Antenna* dark brown; segments four to ten from once to once and a half as long as broad. *Thorax* uniformly dark brown, pollinose, sparsely clothed with dark brown hairs. Scutellum uniformly dark brown; bearing two admedian and two lateral bristles, and a few short hairs. Post-

scutellum dark brown. Pleurae dark brown. *Wings* unspotted; distribution of decumbent hairs similar to that in *C. inornatipennis*, but wings rather less hairy. Halteres darkish brown. *Legs* rather dark brown, almost unicolourous. *Abdomen* dark brown. Spermathecae two, dark brown and very highly chitinised, subspherical to oval, measuring about 35μ by 30μ on an average; only the very commencement of the duct is chitinised.

NIGERIA (Northern provinces): Gimi, Zaria Province, 27th October, 1920 (Dr. W. B. Johnson); 'collected whilst biting.' Duchi-n-wai, about forty miles from Zaria, at an elevation of 2,000 ft. approx., 25th November, 1920 (Mr. L. E. B. Pearse), taken in the act of biting. Ilorin Province, Kaduna river, 21st December, 1920 and 23rd December, 1920; Pategi, 24th December, 1920 (Dr. J. R. C. Stephens); some of the specimens taken on the arm, and undoubtedly biting. Several specimens obtained from each locality, all females.

This species, besides being a much darker brown insect, may be distinguished from *C. inornatipennis* by the following points amongst others: the absence of the characteristic thoracic adornment, the colour of the scutellum and the colour of the halteres.

Culicoides inornatipennis, C., I. and M., var. *rutilus*, var. nov.

A small rufous variety of *C. inornatipennis*, C., I. and M. Length less than 1 mm., usually about 0·8 mm.; length of wing about 0·7 mm., and greatest breadth about 0·3 mm. Hypopygium of the male and spermathecae of the female as in *C. inornatipennis*; other morphological characters also similar. Fourth segment of the palp very small, about half the length of the fifth; scutellum bearing three or four stout bristles, one or two central or admedian and two lateral, and a variable number (about half a dozen usually) of smaller hairs.

Colouration notably different from that of *C. inornatipennis*. Head dark brown. Proboscis and palpi pale brown. Antenna with a dark brown torus and lighter brown flagellum segments, bearing pale brown hairs. Thorax unicolorous, light brown or almost golden-brown. Scutellum light brown; post-scutellum darker but not very dark brown. Pleurae brownish-yellow. Halteres pale

yellowish-brown. Legs pale brown, almost unicolorous, but with knee spots a slightly deeper yellow-brown. Abdomen dark brown.

PUPA. Two pupal pelts were examined, and were found to be indistinguishable from those of *C. inornatipennis.* They were very small, length about 1·3 mm.

GOLD COAST: Nsawam, May to August, 1920; numerous specimens reared from rotting fibrous material taken from the bases of banana stumps. October, 1920; one specimen reared from material taken from a rot-hole in a silk-cotton tree.

Genus *DASYHELEA*, Kieff.

Dasyhelea fuscipleuris, C., I and M.

In a previous paper, Part IV of this study (1921), this species was described. At that time we possessed only two females, taken in buildings, and had identified neither the early stages nor the habitat. Recently we have reared a large number of specimens, and are able to supplement our previous description by giving an account of the pupa. It is interesting to note that all the specimens reared were females and to compare this observation with those previously made on *C. clarkei* and *C. eriodendroni* (1920).

PUPA. Length about 2·1 mm., delicately chitinised and rather slender. *Respiratory trumpets* very long and slender, length about 0·6 mm., breadth about 19μ, raised on small tubercles; the main tracheal trunk is narrow, gives off throughout its length, beginning at its very base, numerous (about fifteen) quite short lateral branches, and ends distally in a cluster of about six short processes. *Cephalothorax* not very strongly chitinised, operculum coarsely shagreened. Anterior marginal tubercle large, conical, bearing a small spine-like hair; dorso-lateral irregularly shaped, bearing two delicate hairs; anterior dorso-median small, bearing two very short, straight hairs; ventro-lateral almost obsolete, bearing two minute hairs, ventro-median represented by a small hair. Dorsum of the thoracic region not infuscated, without tubercles, but with several brownish macules. *Abdomen* feebly chitinised, of the usual form; tubercles small and poorly chitinised, terminal processes widely divergent.

LARVA. The larva is of the usual form. Only a single pelt actually correlated with an adult was obtained, and in it no

characteristic points could be made out. Unfortunately, it was a practical impossiblity to isolate the larvae of this insect from the materials in which they were living, because the sample contained also numerous other species (*Culicoides schultzei*, *C. similis*, *C. austeni*, *C. distinctipennis*, *Stilobezzia spirogyrae* and *Dasyhelea inconspicuosa*).

The single larva reared through to the adult stage was isolated in a small tube containing nothing but a little damp filter paper. The larva buried itself immediately but a day or two later the pupa was observed worming its way to the surface through the mass of filter-paper. The trumpets could not be distinguished with the aid of a hand lens. Two days later a female *C. fuscipleuris* emerged. The pupal pelt was found on the side of the tube half an inch above the filter-paper, a situation which the pupa must have reached by its own unaided efforts. The larval pelt was found embedded in the filter paper near the spot where the pupa was first observed.

GOLD COAST: Accra, April, 1921; numerous specimens (all females) reared from mud taken from the edges of pools and puddles near the station for the Weshiang railway line (Pl. XXI, fig. 2).

Dasyhelea nigricans, C., I. and M.

This species was originally described from two males taken in the laboratory at Accra. The halteres of these specimens had yellowish-brown knobs and dark brown stems. More recently we have received from Dr. W. B. Johnson a number of specimens of a species of *Dasyhelea* taken at Kaduna, Nigeria, in August, 1920, which resembles in every respect *Dasyhelea nigricans*, excepting that in some the halteres are white, and in others yellow. We conclude, therefore, that in this species the colour of the halteres must be variable.

A few of the specimens collected by Dr. Johnson at Kaduna were females, and we are, therefore, able to supplement our previous account by describing the characters of this sex.

MEASUREMENTS.	Female.
Length of body	1·3 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·35 mm.

The female resembles the male in most respects, but the following points, including the more important differences, may be mentioned. *Head*: eyes separated. *Antennae*: hairs dark brown, short and scanty; segments of the flagellum gradually elongating from base to apex in a continuous series, that is without an abrupt change of form between the tenth and eleventh segments; segments four to ten from once to nearly twice as long as broad, segments eleven to fifteen from twice to a little over three times as long as broad, the last segment ending in a stylet; long spines present on all the segments excepting the last five. *Thorax*: scutellum almost entirely yellowish-brown; armature of bristles and hairs as in the male. *Wings* rather densely hairy, the hairs extending basally beyond the cross-vein; bifurcation of the fifth vein at about the same level as the termination of the costa; cell formed by the first and third veins at their junction with the costa larger than in the male. Halteres yellow. *Legs*: claws small, simple, equal. *Abdomen* clothed with yellowish-brown hairs; spermatheca single, highly chitinised, sub-spherical (diameter about 42μ), the commencement of the duct chitinised for a considerable distance, about 15μ, most strongly at its end of origin from the spermatheca.

NIGERIA (Northern provinces): Kaduna, August, 1920 (Dr. W. B. Johnson).

Dasyhelea nigeriae, sp. n.

MEASUREMENTS.	Male.	Female.
Length of body	1·1 mm.	1·1 mm.
Length of wing	0·8 mm.	0·8 mm.
Greatest breadth of wing	0·3 mm.	0·3 mm.

Head dark brown. Eyes separated in both sexes. Clypeus and proboscis dark brown. Palpi dark brown; third segment inflated, in the male especially basally, about the same length as the second; fourth segment short, about half the length of the third. *Antennae* unusually short, dark brown, with dark brown hairs; in the female segments four to fourteen gradually lengthening towards the apex, the length varying from two-thirds to once the breadth, the last segment rather larger and longer and ending in a conical tip, but without a stylet, in the male segments four to eleven short, those at the base broader than long and those at the apex sub-spherical,

length varying from about two-thirds to once the breadth, last four segments sub-equal, about four times as long as broad, not binodose but exhibiting the usual sculpturing (compare *D. flava*), the last segment longer and stouter but without a stylet. *Thorax* uniformly dark brown, with paler, somewhat yellowish, humeral patches. Scutellum dark brown, bearing in both sexes one central, two admedian, and two lateral bristles and no short hairs. Post-scutellum dark brown. Pleurae dark brown. *Wings* hyaline, without spots; clothed with decumbent hairs which do not extend basally beyond the cross-vein. Venation as in *D. flava*; interspace very small in the male, more well developed in the female. Halteres with dusky orange-coloured knobs and infuscated stems. *Legs* brown, femora and tibiae dark brown, but lighter coloured in the male than in the female. Claws short, equal, simple; in the male bifid at the tips. Empodium rudimentary, but in comparison with the size of the claws appearing to be larger than usual. *Abdomen* dark brown, venter slightly paler than the dorsum. Spermatheca single, highly chitinised, pyriform (about 42μ by 38μ); chitinised part at the commencement of the duct conical, about 11μ long.

HYPOPYGIUM (fig. 2). *Ninth segment*: tergite tapering slightly posteriorly, sparsely clothed with strong hairs, posterior margin not

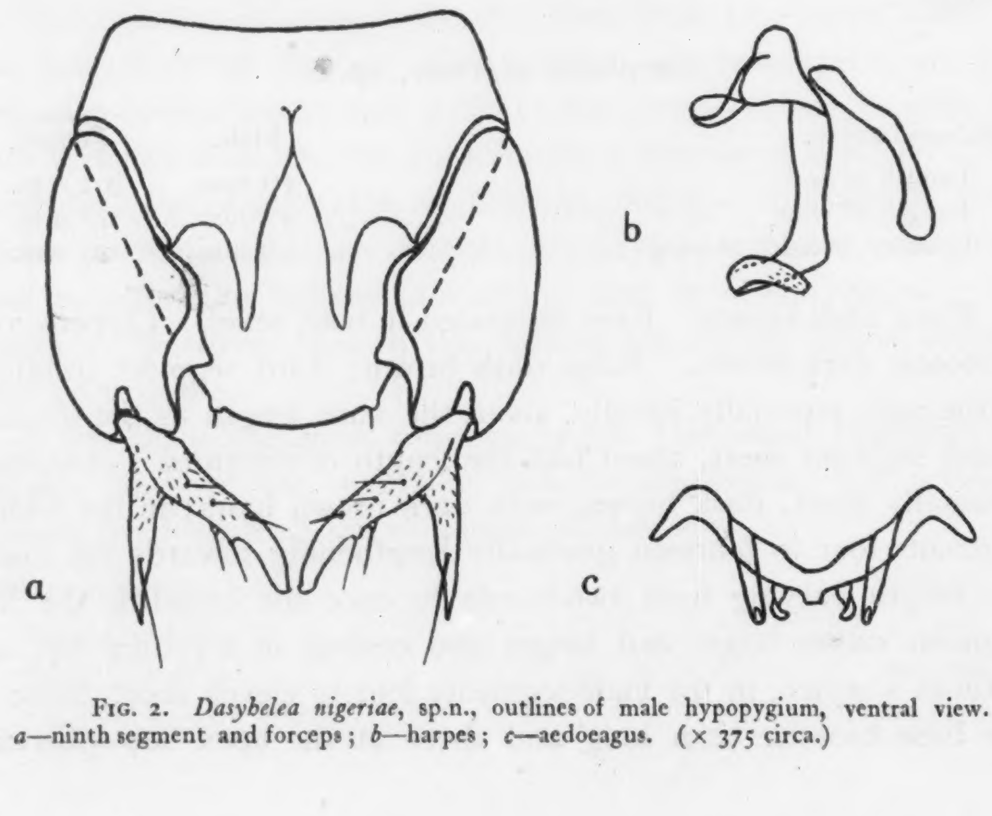

FIG. 2. *Dasybelea nigeriae*, sp.n., outlines of male hypopygium, ventral view. *a*—ninth segment and forceps; *b*—harpes; *c*—aedoeagus. (× 375 circa.)

notched, and without finger-like lateral processes; sternite prolonged posteriorly on each side of the middle line into a highly chitinised, pointed, finger-like process. *Forceps*: side-pieces short and stout, broader apically than basally, rather scantily clothed with moderately long hairs, and bearing on the inner aspect a highly chitinised conical projection; claspers bifid, both parts well developed, pubescent on their basal halves and bearing also a few longer hairs. *Harpes*: basal portions unequal, highly chitinised; from the right basal portion, which is the broader, arises a rather lightly chitinised posterior extension (shaped as shown in the figure), the distal end of which is twisted and covered by minute hairs. *Aedoeagus* broadly-ending, the processes on each side of the horizontal band highly chitinised, finger-like, and curved ventrally at their tips.

NIGERIA (Northern provinces): Kaduna, August, 1920 (Dr. W. B. Johnson). This insect resembles *D. flava* in some respects, but is of an entirely different colour; the hypopygium of the male is characteristic.

Dasyhelea boothi, sp. n.

MEASUREMENTS.

Length of body (one male)	1·0 mm.
Length of wing	0·8 mm.
Greatest breadth of wing	0·25 mm.

Head dark brown. Eyes narrowly separated. Clypeus, proboscis and palpi brown. Third palpal segment not inflated, about as long as the fourth and fifth together, fifth about as long as the fourth. *Antennae*: torus dark brown, flagellum brown; segments four to eleven sub-spherical to ovoid, length from about once to once and a third the greatest breadth; segments twelve to fifteen elongated, sub-equal, but the fourteenth slightly the shortest, the twelfth, thirteenth and fourteenth about three to four times as long as broad, binodose, the fifteenth broader, not ending in a stylet. *Thorax* dark brown. Scutellum pale brown, slightly darker at the sides; bearing two lateral and four centro-marginal bristles, and one small central hair. Post-scutellum dark brown. Pleurae brown. *Wings* sparsely clothed with hairs which extend between the fourth and fifth veins to the level of the cross-vein; venation as usual. Halteres

with brown stems and yellow knobs. *Legs* uniformly brown; claws small, equal, simple, bifid at the tips. *Abdomen* dark brown.

HYPOPYGIUM (fig. 3, *a* to *d*). *Ninth segment*: tergite sparsely clothed with relatively short hairs, tapering distally, posterior margin not notched and bearing double lateral processes; sternite bare, prolonged posteriorly in the middle as a triangular process. *Forceps* not very highly chitinised or hairy: side-pieces rather short

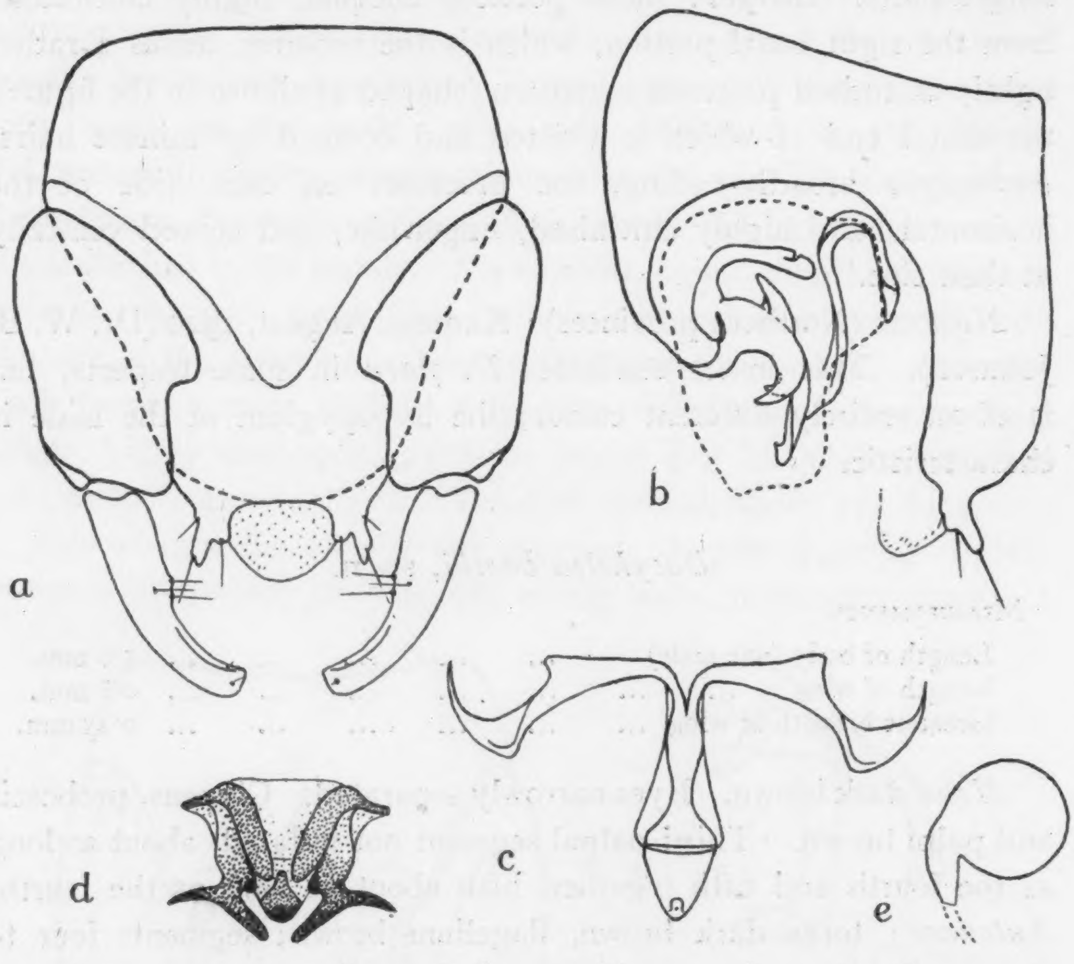

FIG. 3. *a* to *d*—*Dasyhelea boothi*, sp.n., outlines of male hypopygium; ventral view: *a*—ninth segment and forceps; *c*—harpes; *d*—aedoeagus; *b*—lateral view. *e*—*Dasyhelea retorta*, sp.n., spermatheca. (× 300 circa.)

and broad, with a hairy internal apical process; claspers moderately chitinised, with somewhat squared ends, the proximal two-thirds pubescent, bearing three short, stout, hairs about the middle of the inner border. *Harpes* (fig. 3, *b* and *c*) moderately well chitinised, almost symmetrical, composed of a large and irregularly shaped basal plate on each side, and a median common posterior extension which is complex, expanded distally, and with a terminal ventral

barb-like process. *Aedoeagus* (fig. 3, *b* and *d*) very highly chitinised in parts, apparently composed of a pointed median process which is bent ventrally at its tip and in ventral view is pyriform, two short and broad limbs, and external to them somewhat T-shaped extensions.

NIGERIA (Cameroons): Victoria, April, 1921 (Dr. L. H. Booth). We have pleasure in dedicating this species to the collector, Dr. L. H. Booth.

Dasyhelea retorta, sp. n.

MEASUREMENTS.

Length of body (one female)	1·35 mm.
Length of wing	0·9 mm.
Greatest breadth of wing	0·3 mm.

Head dark brown. Eyes very narrowly separated dorsally. Clypeus, proboscis and palpi dark brown. The third segment of the palp cylindrical, not inflated, about as long as the fourth and fifth segments together; the fifth segment shorter than the fourth, widest at its distal end and rounded. *Antennae* dark brown, with dark brown hairs and long curved spines on all the segments of the flagellum; third segment slightly broader than the fourth; segments four to fourteen forming a continuous series, gradually elongating and becoming more flask-shaped, their length varying from about once to once and a half the greatest breadth; the last segment broader and longer, about three times as long as broad, ending in a stylet. *Thorax* dark brown with small yellowish humeral patches. Scutellum almost entirely yellow, sides only slightly infuscated; bearing two lateral and four centro-marginal bristles, and a single central hair. Post-scutellum dark brown. Pleurae brown, lighter than the dorsum. *Wings* with decumbent hairs extending to the base between the fourth and fifth veins. Costa reaching the middle of the anterior border, and terminating beyond the bifurcation of the fifth vein. First and third veins forming a small cell. Halteres with yellow knobs with brown basal infuscation, and brown stems. *Legs* light brown, with dark knee spots and slight infuscation of the distal tarsal segments; hind femora slightly infuscated in the middle dorsally. Claws simple, equal. *Abdomen* dark brown, venter paler than the dorsum, yellowish pigmentation (which

disappears in caustic potash) visible laterally and between the segments. Spermatheca single, highly chitinised, shaped something like a chemical retort (fig. 3 *e*); distal portion sub-spherical, length 44μ, greatest breadth 38μ; proximal portion, the chitinised commencement of the duct, curved, arising obliquely, length about 30μ, width at its middle about 11μ.

SIERRA LEONE: Freetown, May, 1920; one female taken about noon upon a window in the Royal Hotel.

Genus *ATRICHOPOGON*, Kieff.

Atrichopogon africanum, sp. nov.

MEASUREMENTS.

Length of body (one female)	1·4 mm.
Length of wing	1·3 mm.
Greatest breadth of wing	0·4 mm.

Head dark brown, with dark brown hairs. Eyes broadly contiguous above, bare. Clypeus, proboscis and palpi dark brown. First and fourth palpal segments short, second and third longer, fifth somewhat dilated at its distal end; third segment slightly inflated and furnished with a moderately large sensory pit in its distal third. *Antennae* dark brown: segments four to ten short and broad, the tenth sub-spherical; last five segments (eleven to fifteen) elongate, sub-equal, four or five times as long as broad, the fifteenth terminating in a relatively long stylet. *Thorax* uniformly dark brown; clothed with a few short, dark-brown hairs. Pleurae dark brown. Scutellum dark brown, but not so dark as the mesonotum, bearing two sub-median and two lateral bristles and a few (about half a dozen) short hairs. Post-scutellum dark brown. *Wings* (fig. 4) generally similar to those of *A. xanthoaspidium*, unspotted

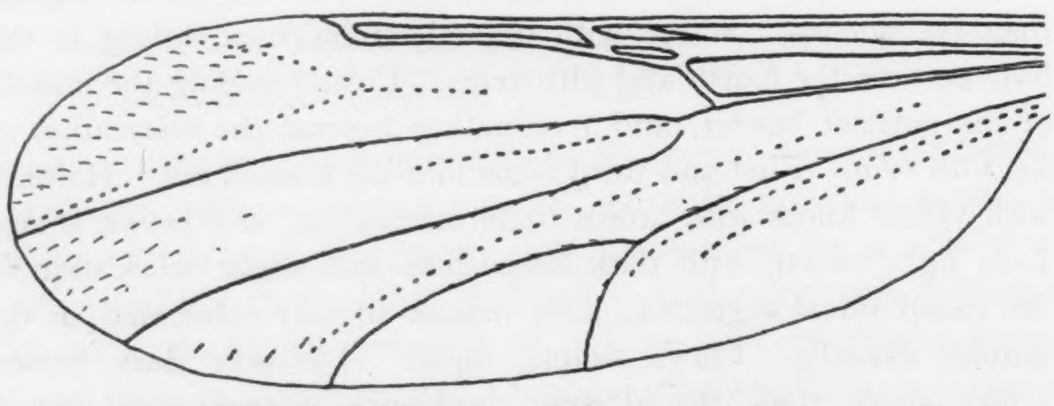

FIG. 4. *Atrichopogon africanum*, sp.n., outline of wing of female. (× 90 circa.)

but slightly infuscated, anteriorly somewhat darker than posteriorly; anterior veins brownish. Surface uniformly covered with microtrichia, and bearing decumbent hairs, which, however, are more scanty than in *A. xanthoaspidium*, none being present between the branches of the fifth vein or in the anal fold, and only a very few between the lower ramus of the fourth vein and the upper ramus of the fifth. Petiolate portion of the fourth vein about the same length as in *A. xanthoaspidium*. Halteres with dark brown knobs. *Legs* almost uniformly brown, but distal segments slightly darker. First tarsal segment of hind legs rather over three times as long as second. Claws simple, equal, about half the length of the fifth tarsal segment. Empodium well developed, as long as the claws. *Abdomen* dark brown, ventral surface slightly paler. Spermatheca (fig. 5) single,

FIG. 5. *Atrichopogon africanum*, sp.n., spermatheca. (× 375 circa.)

large (length 107μ, greatest breadth 84μ), pear-shaped, heavily chitinised; a short portion (about 15μ) of the duct, which is narrow, is chitinised.

GOLD COAST: Accra, August, 1920, one female taken in the evening upon a window in the laboratory.

Atrichopogon elektrophaeum, sp. n.

MEASUREMENTS.

Length of body (one female)	1·4 mm.
Length of wing	1·3 mm.
Greatest breadth of wing	0·5 mm.

Head yellowish-brown. Eyes contiguous above. Clypeus, proboscis and palpi yellowish-brown. First segment of the palp

short; second, fourth and fifth sub-equal, about twice the length of the first; third rather shorter than the combined lengths of the fourth and fifth segments, slightly inflated in the middle, furnished with a sensory cup opening at the junction of the middle and distal thirds; fifth segment somewhat infuscated and tapering distally. *Antennae* brown: first segment poorly chitinised, bearing several short hairs; torus rather a light brown colour, sub-spherical, bearing a few short hairs; third segment wider than any of the other basal segments; segments four to ten short and broad, their lengths varying from about three-quarters to a little over once the breadth; segments eleven to fifteen elongate, cylindrical, sub-equal, four or five times as long as broad, the last the longest and ending in a nipple-like process. All the basal segments of the flagellum bear long, curved, pointed spines. The ratio of the combined lengths of segments three to ten to the combined lengths of segments eleven to fifteen as 0·6 to 1. *Thorax* yellowish-brown, unicolorous, clothed with small brown hairs and bearing larger and darker hairs above the wings. Scutellum pale yellow-brown, bearing two sub-median and two lateral bristles, and about half a dozen small hairs which are dark brown in colour. Post-scutellum yellowish-brown, darker than the scutellum. Pleurae yellowish-brown. *Wings* with a pale yellowish tint, similar to those of *A. xanthoaspidium* but with fewer hairs, none being present between the fourth and fifth veins nor between the rami of the fifth vein, and only a row of eight along the false vein in the anal angle. Halteres with pale yellow-brown knobs. *Legs* almost uniformly yellowish-brown, terminal segments of the tarsi, however, slightly darkened. First tarsal segment on all the legs about three times as long as the second. Claws simple, equal, about half the length of the fifth tarsal segment. Empodium well developed, as long as the claws. *Abdomen* yellowish-brown, rather darker than the thorax; venter paler than the dorsum. Spermatheca single, highly chitinised, oval, large, length 106μ, greatest breadth 80μ; the duct not chitinised.

GOLD COAST: Accra, 1920; taken in the evening upon a window in the laboratory.

Atrichopogon perfuscum, sp. nov.

MEASUREMENTS.

Length of body	1·3 mm.
Length of wing	1·1 mm.
Greatest breadth of wing	0·4 mm.

Head dark brown, clothed with dark brown hairs. Eyes broadly contiguous above, smooth. Clypeus, proboscis and palpi dark brown. *Antennae* dark brown; segments four to ten short and broad, the tenth sub-spherical the others broader than long, the length varying from two-thirds to three-quarters the breadth; the last five segments (eleven to fifteen) elongate, about three times as long as broad. *Thorax* uniformly dark brown. Pleurae dark brown. Scutellum dark brown, but rather lighter coloured than the mesonotum, bearing two sub-median and two lateral bristles and several (six to eight) short hairs. Post-scutellum dark brown. *Wings* clear, unspotted; venation and decumbent hairs as in *A. xanthoaspidium*, but fewer hairs present between the rami of the fifth vein and in the anal angle (only two being present in the former situation and one or two in the latter in one of the specimens examined, rather more in the others). Halteres with buff-coloured knobs and dark brown stems. *Legs* almost uniformly yellowish-brown, but tarsal segments slightly infuscated. Claws equal, about half the length of the fifth tarsal segment, each with a very small sub-apical tooth. Empodium well developed, as long as the claws. *Abdomen* dark brown. Spermatheca single, highly chitinised, oval; length from 70μ to 87μ, greatest breadth from about 57μ to 65μ, the duct chitinised for only a short distance (about 5μ) at its commencement.

GOLD COAST: Accra, October, 1920; three females collected in the evening upon the windows of the laboratory.

Atrichopogon chrysosphaerotum, sp. nov.

MEASUREMENTS.

Length of body (two females)	1·15 mm.
Length of wing	0·9 mm.
Greatest breadth of wing	0·35 mm.

Head dark brown, clothed with dark brown hairs. Eyes broadly contiguous above, bare. Clypeus, palpi and proboscis dark brown.

First palpal segment short; second, third and fourth longer, sub-equal; fifth rather shorter; third segment moderately inflated and furnished with a well developed sensory pit. *Antennae* dark brown, segments four to ten short and broad, the tenth sub-spherical, the others broader than long, the length varying from half to about two-thirds the breadth; last five segments (eleven to fifteen) elongate, from two and a half to three times as long as broad, the fifteenth terminating in a relatively large stylet. *Thorax* uniformly dark brown, scantily clothed with brown hairs. Pleurae dark brown. Scutellum dark brown, bearing two sub-median and two lateral bristles and no short hairs. Post-scutellum dark brown. *Wings* clear, unspotted, the anterior veins brownish; venation as in *A. xanthoaspidium*, but first cell larger; decumbent hairs absent, wing surface covered by microtrichia. Halteres with yellow knobs and pale straw-coloured stems. *Legs* almost uniformly yellowish-brown, but tarsal segments slightly infuscated. Fourth tarsal segments not cordiform; first tarsal segment of hind legs nearly four times as long as second; dorsal hairs on the tarsal segments rather long. Claws equal, apparently simple or with a very minute sub-apical tooth, about half the length of the fifth tarsal segment. Empodium well developed, as long as the claws. *Abdomen* dark brown with a yellowish tint, pigmented with a substance which does not clear in carbolic acid but which is removed by caustic potash. Spermatheca single, highly chitinised, oval; length 57μ, greatest breadth 46μ, only the very commencement (about 4μ) of the duct is chitinised.

GOLD COAST: Accra, November, 1920; a single female, collected in the evening upon a window in the laboratory. Oblogo, May, 1920, reared from rotten wood from a canoe in the river Densu.

Atrichopogon homoium, sp. nov.

This species, of which we possess only a single female, agrees with the foregoing (*A. chrysosphaerotum*, sp. nov.) in size, colouration, and apparently in every other particular excepting in the distribution of the hairs on the wings and the scutellum. On the scutellum are four short hairs, two on each side, in addition to the bristles. On the wings are a few decumbent hairs; seven to ten at

the tip of the wing, one near the periphery between the rami of the fourth vein, and a few along the distal portion of the anterior ramus of the fourth vein (fig. 6).

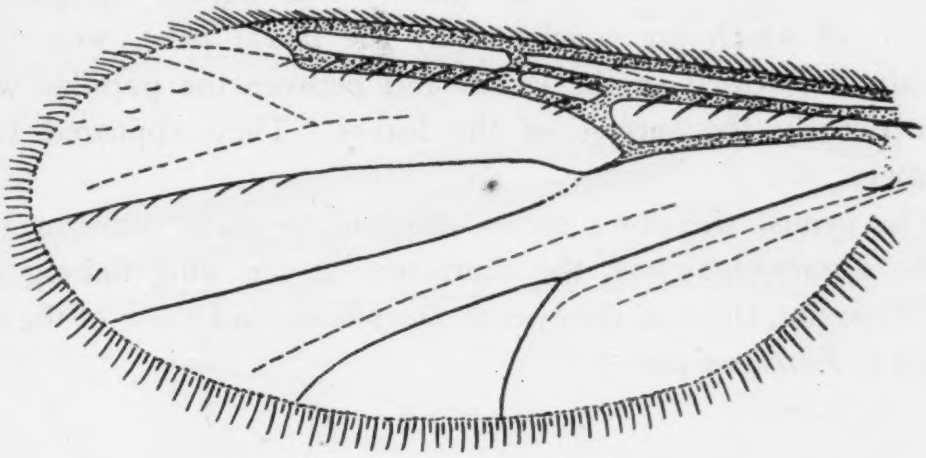

FIG. 6. *Atrichopogon homoium*, sp.n., wing of female. (× 120 circa.)

The distribution of the hairs on the wings and the scutellum appear to be important specific characters, and therefore, notwithstanding the similarity of this insect to *A. chrysosphaerotum* and the paucity of our material, we feel compelled to regard it as a separate species.

GOLD COAST: Oblogo, September, 1920; a single female reared from material taken from a canoe.

Genus *KEMPIA*, Kieff.

This genus, originally described by Kieffer (1913) as a sub-genus of *Dasyhelea* and subsequently raised to generic rank by its author and removed to the *Atrichopogon* group, appears to be characterised chiefly by the presence of a well developed empodium on the legs and of pubescence on the eyes, and the absence of the longer hairs from the wings. We have referred the insect described below to the genus *Kempia*, notwithstanding the fact that it bears on its wings a few decumbent hairs, because, as stated elsewhere, we are inclined to regard this character as of specific rather than generic value. It may be noted, however, that in the case of *Prokempia* the absence of the longer wing hairs appears to have been considered by Kieffer sufficient justification for its separation from *Dasyhelea*.

The larvae and pupae resemble those of *Forcipomyia*. The larvae were found living upon the water lettuce *Pistia stratiotes*, but were normally seldom seen alive, probably because they were buried in the substance of the plant. The pupae, the posterior portions of which are enveloped by the larval pelts, were found partially embedded in the leaves and between the papillae which cover densely the surface of the leaves. They appeared to be sedentery.

The genus, therefore, shows affinities to three different types of the *Ceratopogoninae*, the characters of the wing linking it to *Atrichopogon*, those of the eyes to *Dasyhelea*, and those of the early stages to *Forcipomyia*.

Kempia ochrosoma, sp. nov.

MEASUREMENTS.

Length of body	1·3 mm.
Length of wing	1·1 mm.
Greatest breadth of wing	0·35 mm.

Head straw-yellow, clothed with yellow hairs. Eyes pubescent: in the female contiguous, but with the facets narrowly separated; in the male separated. Clypeus, palpi and proboscis pale straw-yellow, with similarly coloured hairs. First palpal segment small, second and fourth sub-equal, fifth short and somewhat expanded at its distal end, third longer than any of the others, slightly inflated in its middle third, and furnished with a deep sensory cup. *Antennae*: first segment and torus straw-yellow; in the female, flagellum segments slightly infuscated, especially the more distal ones, segments eleven to fifteen dark brown; in the male, segments three to eleven pale yellow, segment twelve dark distally, and the last three segments dark brown; whorls of hairs pale straw-yellow. In the female, segments four to ten sub-spherical, the length varying from a little less than to about the same as the breadth, segments eleven to fifteen elongate, from twice to three times as long as broad, the last segment terminating in a stylet. In the male, the last three segments elongate, sub-equal, the thirteenth slightly the longest and the fifteenth terminating in a stylet. *Thorax* uniformly coloured, ochraceous, almost the same hue as the head; clothed with short, curved, yellow hairs dorsally, and with a few longer, spine-like,

yellow hairs posteriorly. Pleurae ochraceous. Scutellum slightly paler yellow than the mesonotum, bearing two admedian and two lateral bristles and a few (ten in the female, eight in the male) short hairs. Post-scutellum ochraceous. *Wings* unspotted, the anterior veins yellowish; venation as shown in the figure (fig. 7). Decumbent

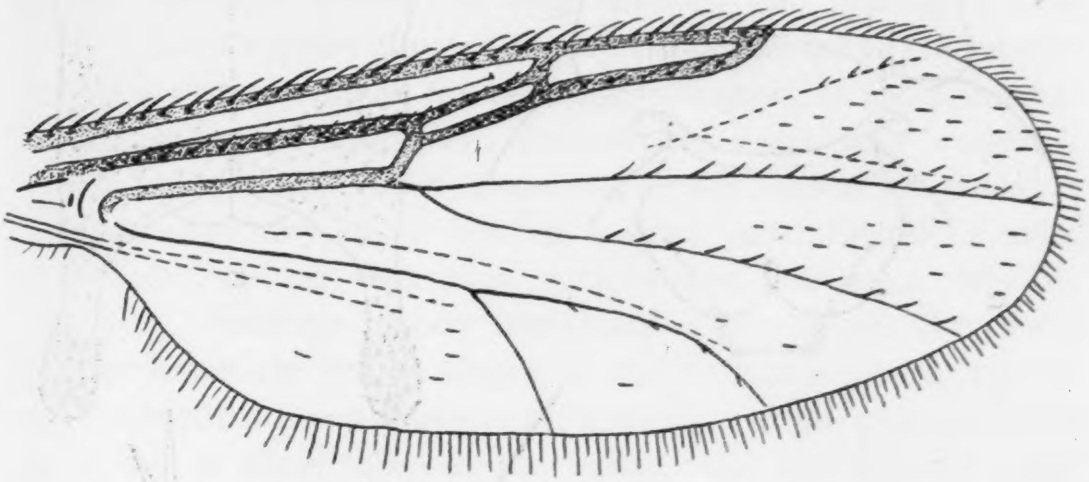

FIG. 7. *Kempia ochrosoma*, sp.n., wing of female. (× 90 circa.)

hairs scanty: in the female, limited to the distal third of the wing and a few near the posterior margin; in the male, almost entirely wanting. Surface of the wing closely covered with microtrichia. Halteres with pale straw-yellow stems and white knobs. *Legs* almost uniformly pale straw-yellow; unarmed. Claws in both sexes equal, about half the length of the fifth tarsal segment; in the female, each with a very small, sub-apical tooth, in the male, deeply bifurcated at the tips. Empodium well developed, hairy; at least as long as the claws. *Abdomen* ochraceous, rather paler yellow than the thorax. Hypopygium of the male of a similar colour and feebly chitinised. Spermatheca single, rather feebly chitinised, obovate and very large; length about 230μ, greatest breadth about 150μ, the duct chitinised at its commencement for a short distance (about 10μ). The abdomen, and also the thorax and the knobs of the halteres, containing a yellowish pigment which is not cleared by carbolic acid but which dissolves in caustic potash.

HYPOPYGIUM (fig. 8 *a* and *b*). *Ninth segment* feebly chitinised; tergite rather short and hairy, posterior margin rounded, without lateral, finger-like processes. *Forceps*: side-pieces normal, feebly chitinised; claspers also feebly chitinised, about as long as the

side-pieces, tapering distally, hairy almost to their tips. *Harpes* apparently absent. *Aedoeagus* feebly chitinised, a large ventral median structure with a central and two lateral processes; when fully

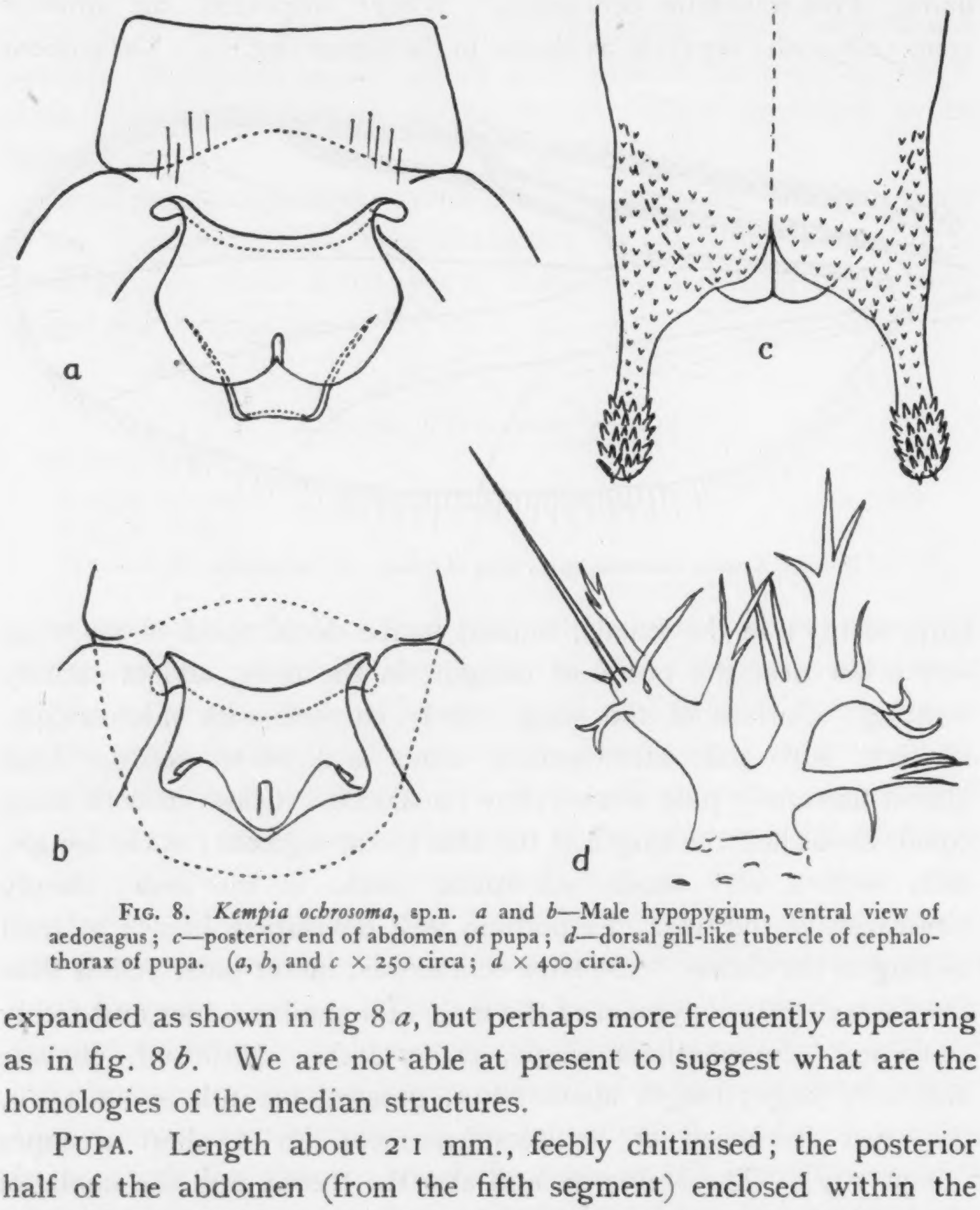

FIG. 8. *Kempia ochrosoma*, sp.n. *a* and *b*—Male hypopygium, ventral view of aedoeagus; *c*—posterior end of abdomen of pupa; *d*—dorsal gill-like tubercle of cephalothorax of pupa. (*a*, *b*, and *c* × 250 circa; *d* × 400 circa.)

expanded as shown in fig 8 *a*, but perhaps more frequently appearing as in fig. 8 *b*. We are not able at present to suggest what are the homologies of the median structures.

PUPA. Length about 2·1 mm., feebly chitinised; the posterior half of the abdomen (from the fifth segment) enclosed within the larval pelt, which is much shrivelled and discoloured. Integument irregularly covered with rather sparsely scattered spicules. *Cephalothorax* relatively large and broad, somewhat of the *Forcipomyia* type but with no dorsal extension over the middle of the first abdominal segment. Respiratory trumpets almost smooth, short and nearly straight, length a little less than 0·2 mm.; they arise from

small tubercles and are without stalks. Main tracheal trunk does not give off any lateral branches, and ends distally in a double row of rather long, blunt processes. Operculum feebly chitinised, sparsely spiculated; at its posterior angle is a small tubercle covered with long spicules. Anterior marginal tubercle an irregularly conical elevation covered by long spicules, and bearing a long bristle; anterior dorsal situated posterior and external to the anterior marginal and anterior to the base of the trumpet, a small tubercle bearing a rather long hair; dorso-lateral apparently unarmed, except by spicules; ventro-lateral apparently absent or obsolete; ventro-median very small, bearing a short hair. Dorsal tubercles remarkable, six on each side, each giving rise to a delicate, branching, dendritic process resembling a sort of gill (fig. 8 *d*); these processes are well developed on all the tubercles excepting the small admedian pair situated a little anterior to the most posterior pair; two of these tubercles are armed, the two situated most anteriorly and internally, and bear long spines. *Abdomen* directed straight backwards, tapering rather rapidly, the last segment terminating on each side in an almost straight process which is slightly dilated at its distal end, and is covered with long spicules directed anteriorly, which no doubt function as hold-fasts (fig. 8 *c*). The segments, which are enclosed within the larval pelt, bear only rudimentary tubercles; on the other segments (one to four) are a pair of dorsal admedian, and a pair of lateral tubercles similar to those on the dorsum of the cephalo-thorax—that is, dendritic processes resembling gills—the dorsal ones bear large spines.

LARVA. Length about 3 mm. when fully grown, brownish in colour. *Head* moderately chitinised, more or less conical, bearing a few relatively large hairs or bristles. Horn-like appendages on the dorsum (which are connected with the distal ends of the antennae of the adult) small, narrow, about 0·06 mm. long, straight, arising from quite small tubercles. Eyes large, bilobed. Mandibles densely chitinised, black, terminating in three or four teeth. Hypopharyngeal sclerite very highly chitinised, the posterior part armed on each side with a comb-like row of about ten short, pointed teeth. *Body* composed of twelve visible segments; cuticle covered with coarse spicules. Armature of bristles, spines, etc., modified at the anterior and posterior ends, but general arrangement as follows.

A pair of finger-like, admedian dorsal tubercles, bearing long spines, which are more or less barbed at their bases; three pairs of very long (about 0·8 mm.) and delicate dorso-lateral processes; four pairs of ventral spines, two central, the one admedian and the other ventro-lateral, and two postero-marginal, both ventro-lateral, these spines are relatively short and are freely barbed. The long dorso-lateral processes are the most conspicuous features of the larva, they bear lateral spines or bristles, are directed backwards, and trail behind the larva. The pro-thoracic pseudopods are partially fused, highly spiculated, each armed with a group of about ten large, well developed hooks, and anteriorly with numerous small hooks. The anal pseudopods are armed with similar large hooks arranged in two transverse rows.

GOLD COAST: Oblogo, February to March, 1921; reared from plants of the water lettuce (*Pistia stratiotes*) taken from a swampy pool, and from backwaters of the river Densu (Pl. XXI, fig. 1).

Genus *MONOHELEA*, Kieffer.

This genus is stated by its author to possess the characters of *Stilobezzia*, Kieff., but the petiole of the fourth longitudinal vein is very short, the fourth tarsal segment is long and cylindrical, the claws of the fore and middle legs of the female are simple, equal, two-thirds the length of the last tarsal segment, and the claws of the hind legs single, longer than the last tarsal segment. The species described below, of which at present we possess only a single female, appears to belong to this genus, although not conforming exactly to the generic description given above (for example, the claws of the fore and middle legs are not simple). The insect superficially resembles *Stilobezzia*, and when at rest holds its wings in a manner similar to *S. spirogyrae*, that is, diverging slightly, and not folded one on top of the other on the dorsum of the abdomen.

Monohelea litoraurea, sp. n.

MEASUREMENTS.

Length of body (one female)	1·3 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·4 mm.

Head: occiput dark grey to brown, clothed with dark brown hairs. Eyes smooth, contiguous dorsally. Clypeus and proboscis

dark brown. Palpi dark brown, third segment slightly inflated and furnished with a sensory cup; fifth segment rather long and narrow, with a terminal group of four hairs. *Antennae* darkish brown: first segment rather large, dark brown, bearing a few dark hairs; torus dark brown, bearing a few dark hairs; flagellum segments paler, gradually elongating and deepening in colour towards the distal end of the antenna; fourth to tenth segments sub-cylindrical, from about one and a third times to twice as long as broad; segments eleven to fifteen elongate, from about three to a little over four times as long as broad, the last segment being the largest and the longest and tapering at its extremity, but not terminating in a definite stylet. Whorls of hairs small and the constituent hairs short; there is a hair just before the tip of the last segment. *Thorax*: dorsum dark grey with many dark brown spots and patches, and with the antero-

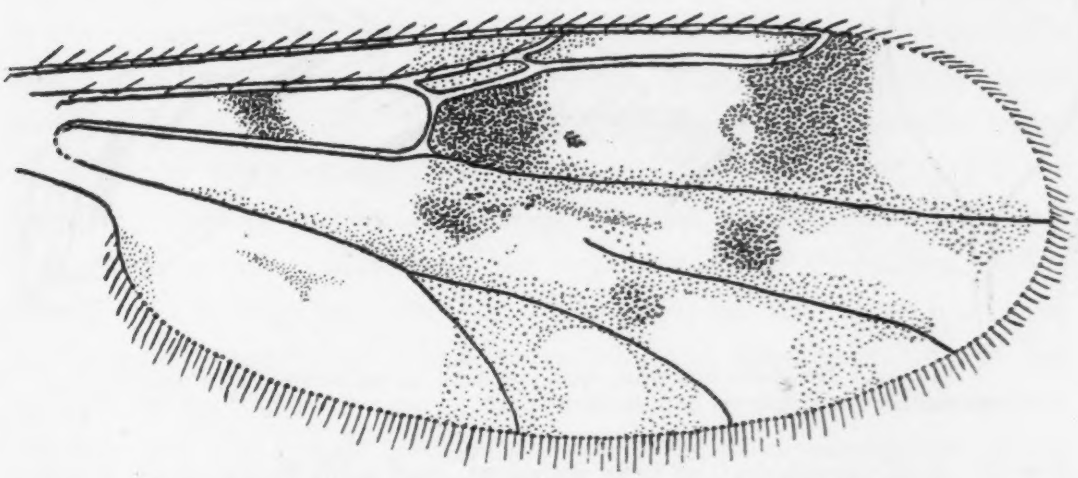

FIG. 9. *Monobelea litoraurea*, sp.n., wing of female. (× 105 circa.)

lateral angles brownish-yellow. The arrangement of the spots and patches is somewhat like that on the thorax of *Culicoides schultzei*. The mesonotum is clothed with rather short, dark hairs. Pleurae dark brown. Scutellum darkish brown, but not so dark as the mesonotum, paler in the middle than at the sides, bearing two admedian and two lateral bristles and a few (six) short hairs. Post-scutellum dark brown. *Wings* grey, with large white patches; the arrangement of the patches and the venation as shown in fig. 9. Lower ramus of fourth vein obsolete at the proximal end. The surface of the wing is covered by microtrichia, but without larger decumbent hairs. Halteres pale, with white knobs. *Legs* brown, femora and tibiae more or less infuscated. Fore and middle

femora brown, somewhat infuscated, especially at their apices, not swollen and without strong spines; hind femora uniformly very dark brown, slightly swollen, without strong spines. Fore and middle tibiae brown, infuscated; hind tibiae uniformly very dark brown, somewhat swollen. Tarsal segments brown, paler than the proximal segments: fore and middle tarsi without regularly arranged rows of spines, fore tarsi with a well developed black spine at the apex, the base, and sometimes the middle of the first segment and somewhat smaller but similar spines at the apex of the second and third segments, middle tarsi with several similar but less well defined spines, on the first segment and at the apex of the second and third segments, hind tarsi (fig. 10 *a*) with a regularly arranged ventral

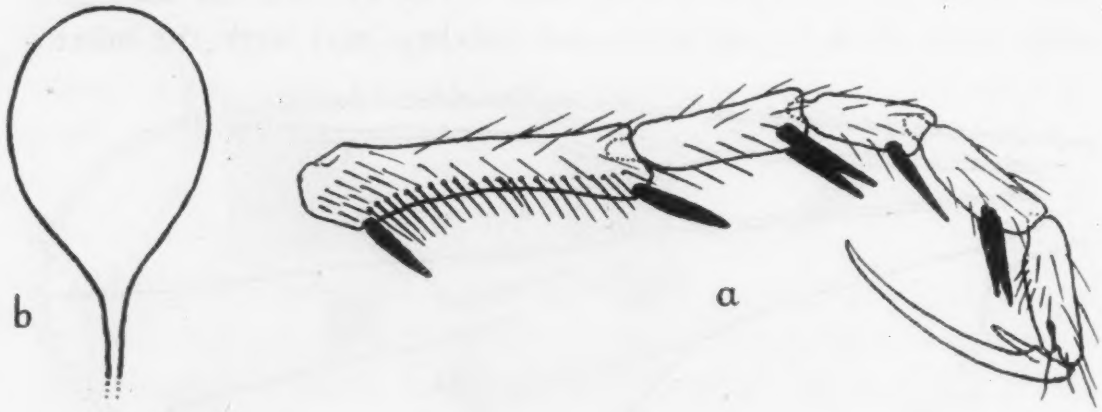

FIG. 10. *Monobelea litoraurea*, sp.n. *a*—hind tarsus of female (× 190 circa); *b*—spermatheca of female (× 375 circa).

row of small spines on the first segment, and with large black spines, one at the apex and one at the base of the first segment, two at the apex of the second segment, one at the apex of the third segment, and two at the apex of the fourth segment. Fourth tarsal segment on all the legs cylindrical. Claws on the fore and middle legs small, about half the length of the fifth tarsal segment, equal, each with a small basal tooth and a bifid extremity; claws on the hind legs single, with a very long tooth (as long as the fourth and fifth tarsal segments together), and a short tooth apparently fused with the large tooth at the base. Empodium rudimentary. *Abdomen* very dark brown, excepting at its extreme proximal end, where it is yellowish-brown; distal end almost black. Dorsal surface very sparsely clothed with short, dark hairs, which are almost entirely restricted to the sides. Spermathecae (fig. 10 *b*) two, unequal,

highly chitinised, pyriform (measurements about 80μ by 55μ, and 65μ by 55μ); the commencement of the duct, which is narrow (about 4μ), is chitinised for some distance (about 20μ).

GOLD COAST: Accra, 27th March, 1921; collected on a window in the laboratory at 6 p.m.

Genus *EUKRAIOHELEA*, nov.

The two following species show kinship to the genus *Stilobezzia*, Kieff., the chief generic characters of which are, according to Kieffer (1919)—wings glabrous, the first and third veins forming two radial cells of which the second is the longer, the fourth vein petiolate, the fourth tarsal segment cordiform in both sexes, and the claws long, simple, and very unequal in the female, short and equal in the male. Thy possess the above characters excepting that the first radial cell of the wing is obsolete, the first and third veins forming only a single large cell, but they show certain other divergencies from earlier descriptions given by Kieffer (1917), for example, the fore femora are armed but not swollen, and the hind tibiae beaı spines. Moreover, the hypopygium of the males, whilst closely resembling one another, diverge from the type found in *Stilobezzia spirogyrae*. These morphological differences are, in our opinion, of such a nature as to necessitate the separation of these two species from the genus *Stilobezzia*, and, therefore, notwithstanding their close similarity in other respects to species of that genus, we propose to regard them as belonging to a new genus, for which we suggest the name *Eukraiohelea*.

Eukraiohelea africana, sp. n.

MEASUREMENTS.	Male.	Female.
Length of body	1·3 mm.	1·4 mm.
Length of wing	1·2 mm.	1·3 mm.
Greatest breadth of wing	0·4 mm.	0·5 mm.

The ground colour of this insect is olive green, on which are superimposed the brown markings. *Head* brown. Eyes smooth; narrowly separated in the female, more widely in the male. Clypeus and proboscis dark brown. Palpi dark brown, moderately long,

the third segment slightly inflated distally and furnished with a shallow sensory cup near its apex. Mouth-parts well developed in the female. *Antennae*: first segment small; torus yellowish-brown, sub-globular, very large in the male, bearing a few short hairs; flagellum pale brown proximally, the last three segments in the male and five in the female dark brown. Plume of the male moderately well developed, pale brown; hairs of the flagellum of the female very short, brown. In the male, the last three segments of the flagellum elongated, the thirteenth and fourteenth about five and twelve times as long as broad respectively, the fifteenth much longer, about thirty times as long as broad, and ending in a short, stout process. In the female, segments four to ten pale brown proximally, dark brown distally, and segments eleven to fifteen all dark brown; segments four to ten sub-cylindrical, rather wider in the middle than at either end, sub-equal, about three times as long as broad;

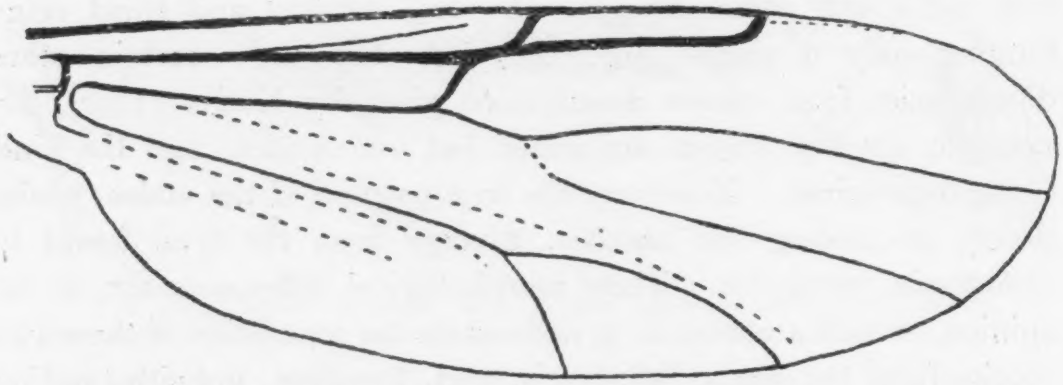

FIG. 11. *Eukraiobelea africana*, sp.n., venation of wing of male. (× 90 circa.)

segments eleven to fourteen elongated, about ten times as long as broad; the last segment much longer, about twenty times as long as broad, ending in a short, stout process. *Thorax* blue-green, with brown infuscation on the dorsum; hairs large, scanty, dark brown. Pleurae blue-green; a dark brown spot on the coxae of the fore and middle legs. Thoracic pits absent. Scutellum blue-green in the middle, and brown, with a blue-green tint, at the sides; bearing two admedian and two lateral bristles and a few (two to four, but often absent in the male) short hairs. Post-scutellum dark brown with a greenish-blue tint. *Wings* unspotted, without decumbent hairs. Wing surface covered by microtrichia. Venation as shown in the figure (fig. 11); first radial cell obsolete; in the female, the fourth

vein forks distally to the fifth, in the male, they both fork at about the same level. Fringe very short on the distal part of the wing. Halteres with greenish-blue knobs; stalks almost white, bases of the knobs infuscated. *Legs* pale brown, almost colourless, with dark knee spots; the infuscation on the hind legs extending beyond the knee nearly half way down the tibia. Fore femora armed with two short, stout, ventral spines, middle and hind femora unarmed; hind femora slightly swollen, fore and middle normal. Fore tibiae with the usual long apical spine; hind tibiae with a ventral row of spines, three long ones on the middle third and four short ones more distally. On all the legs the first tarsal segment at least twice as long as the second, third small and almost cordiform, fourth very small and strongly cordiform, fifth slightly infuscated, about as long as the second and longer than the third and fourth together. Rows of bulbous spines present on the first and second tarsal segments of all the legs; a stout basal spine on the first tarsal segment of the middle and hind legs; on the proximal half of the fifth tarsal segment of the fore and middle legs are two pairs of stout spines, on the hind legs a single pair. Claws alike on all the legs: in the female, single, with a long tooth (as long as the fifth tarsal segment), and a tooth about half this length apparently fused with it at the base, which is, moreover, somewhat extended as a process; in the male, shorter (about two-thirds the length of the fifth tarsal segment), bifid at the tips, composed of two equal parts fused at their bases. Empodium absent. *Abdomen* green, with brown infuscation (which is most marked in the female) at the sides and posterior dorsal margins of the segments. First segment with conspicuous lateral tufts of hairs. Spermathecae two, highly chitinised, pyriform (about 46μ by 35μ); the commencement of the duct chitinised for a short distance (about 7μ) only.

Hypopygium (fig. 12). *Ninth segment*: tergite rather feebly chitinised, moderately hairy; posterior margin broad, not cleft, without finger-like lateral processes; apical lobe-like processes moderately well developed, hairy; sternite apparently not excavated in the middle posteriorly. *Forceps*: side-pieces moderately long and hairy, distal ends infuscated; claspers rather broad, not strongly chitinised, tips infuscated, clothed with very delicate minute hairs and bearing a few longer hairs. *Harpes* in form somewhat

resembling those of species of *Dasyhelea*, but with the distal extensions bilateral and separate. Basal portions irregularly shaped, broad laterally; posterior extensions long, lath-like processes directed almost straight backwards, with bluntly pointed tips, reaching posteriorly as far as, or a little further than the margin

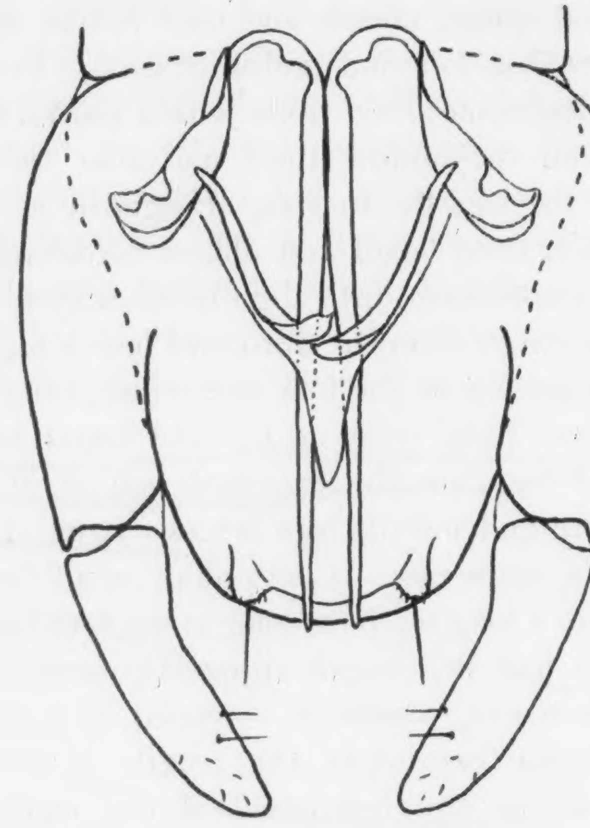

FIG. 12. *Eukraiobelea africana*, sp.n., outline of male hypopygium, ventral view. (× 375 circa.)

of the ninth tergite. *Aedoeagus* apparently composed of two separate chitinised lateral rods corresponding to the limbs of the arch in other genera, and a delicate membranous portion enclosing them and prolonged posteriorly in the middle line as a conical process. Ventral wall not spiculated.

GOLD COAST: Swamp between Koforidua and Tafo, a little north of Accra, April, 1921; Weshiang, June, 1921; reared from plants of the water-weed *Pistia stratiotes*.

Eukraiohelea versicolor, sp. n.

MEASUREMENTS.	Male.	Female.
Length of body	1·3 mm.	1·3 mm.
Length of wing	1·0 mm.	1·1 mm.
Greatest breadth of wing	0·3 mm.	0·4 mm.

This insect resembles the last species, but the ground colour is white instead of blue-green. In the following account, only the more important points of difference between it and *Eukraiohelea africana* will be given.

Head dark brown; occiput dark brown in the middle, paler at the periphery; median occipital hairs long, dark brown. Eyes during life metallic green; smooth, separated in both sexes. Proboscis dark brown, well developed in the female. Palpi dark brown, as in *E. africana*. *Antennae*: torus yellowish-brown; flagellum very pale brown at the base, last five segments in the female and three in the male completely dark brown, apical portions of the fourth to the tenth segments in the female infuscated. Plume in the male moderately well developed, pale brown, hairs in the female short, pale brown. In the male, the last three segments elongated, about five, twelve, and twenty-two times as long as broad respectively, the last segment tapering to a conical tip. In the female, segments four to ten as in *E. africana*; segments eleven to fourteen elongate, sub-equal, about eight or nine times as long as broad; segment fifteen longer, about twelve times as long as broad, ending in a conical tip. *Thorax*: ground colour white; anterior half of the dorsum almost entirely dark brown in the male, in the female more or less infuscated and dark brown, but with median pale areas on each side of the middle line; in front of the scutellum is a triangular dark brown mark with its base directed posteriorly. Pleurae white. Over the bases of the coxae is a small, oval, dark brown patch. Scutellum dark brown, armature of bristles and hairs as in *E. africana* Post-scutellum dark brown. *Wings* as in *E. africana*. Halteres white. *Legs*: ground colour white; distal half of the hind femora and apical sixth of the hind tibiae dark brown; fifth tarsal segments hardly infuscated. Coxae infuscated. Femora shaped and armed as in *E. africana*. Tibiae shaped and armed as in *E. africana*, but hind tibiae bearing only three long spines. Tarsal segments as in *E. africana*; spines

on the fifth segments, however, less well developed, arrangement in the female as in *E. africana*, in the male only one pair present on all the legs. Claws as in *E. africana*. *Abdomen* white, with dark brown markings arranged as follows: small lateral patches on the first, fourth, and seventh segments, large dorso-lateral patches, reaching almost to the middle line dorsally, on the second, third, fifth and sixth segments. Lateral hair tufts on the first segment not so prominent as in *E. africana*. Spermathecae similar to those of *E. africana*; two, highly chitinised, pyriform (about 35μ by 30μ), the commencement of the duct chitinised for a short distance (about 4μ) only.

Hypopygium (fig. 13). Hypopygium darkish brown, rather small. *Ninth segment*: tergite moderately hairy, tapering slightly distally, posterior margin nearly straight, with a trace of a median

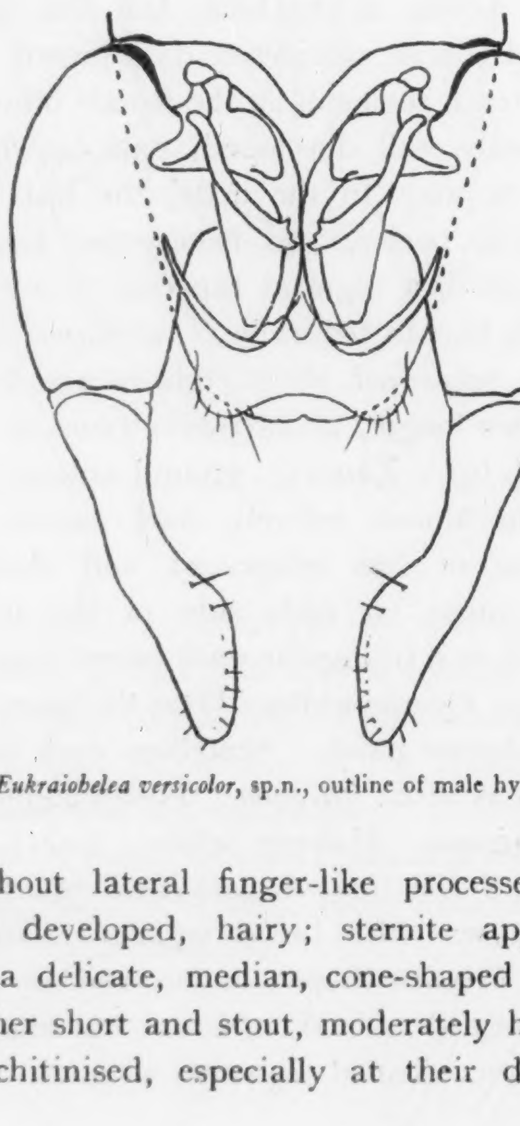

Fig. 13. *Eukraiobelea versicolor*, sp.n., outline of male hypopygium, ventral view. (× 375 circa.)

cleft, but without lateral finger-like processes; apical lobe-like processes well developed, hairy; sternite apparently prolonged posteriorly as a delicate, median, cone-shaped process. *Forceps*: side-pieces rather short and stout, moderately hairy; claspers long, stout, feebly chitinised, especially at their distal ends, entirely

covered by very delicate minute hairs and bearing at the posterior extremity a few rather larger hairs. *Harpes* similar to those of *E. africana*, but basal portions more expanded laterally, and posterior extensions longer and bent sharply in an anterior direction at about their middles. *Aedoeagus* somewhat similar to that of *E. africana*, delicate membranous part apparently with large lateral folds; ventral wall not spiculated.

GOLD COAST: Swamp between Koforidua and Tafo, a little north of Accra, April, 1921; reared from plants of the water-weed *Pistia stratiotes*.

Genus *SCHIZODACTYLUS*, nov.

This genus is allied to *Xylocrypta*, Kieff., and *Xenohelea*, Kieff., genera which have been separated by Kieffer (1917) from *Sphaeromias* (Stephens), Curtis, and *Palpomyia*, Mergele, by the characters of the fourth tarsal segments, which are cylindrical in both sexes, and the antennae of the males, only the last three segments of which are elongated. From the former it may be distinguished by the facts that the eyes in the male are separated and the body is not squat; from the latter by the fact that the claws of the female are equal. The chief generic characters are as follows:—Eyes smooth, separated in both sexes; widely in the male, narrowly in the female; last three segments of the antenna of the male elongate; wings covered by microtrichia but without longer decumbent hairs, costa reaching beyond the middle of the wing, first and third veins forming two radial cells, the distal of which is the longer, cross-vein not very oblique and not twice as long as the base of the cubitus, fourth vein sessile; femora armed, fourth tarsal segments cylindrical, claws in the female long and equal, those on the fore legs with long basal barbs, empodium rudimentary.

Schizodactylus telmatoscopus, sp. n.

MEASUREMENTS.

Length of body (two males)	2·8 mm.
Length of wing	1·5 mm.
Greatest breadth of wing	0·5 mm.

Head dark brown, large, wider than the thorax. Eyes glabrous, widely separated. Proboscis dark brown, very short. Palpi

brown, very small; third segment not inflated, sensory pit small or rudimentary. *Antennae* rather dark brown, especially the torus and the three terminal segments. First segment without hairs; torus sub-spherical, very dark; third segment rather larger than the following segments; fourth to twelfth segments almost cylindrical, from one and a third to two and a half times as long as broad, sharply separated from one another; last three segments elongated, the fifteenth being the longest and not ending in a stylet. Hairs not very long, pale coloured, arranged somewhat irregularly and not forming a single whorl. *Thorax* uniformly dark brown; small pro-thoracic lobes present; no tubercle on the front margin of the thorax in the middle; dorsum almost devoid of bristles, and without either anterior or posterior pit-like depressions. Scutellum dark brown, bearing a few (twelve to fourteen) hairs, but no large bristles. Post-scutellum dark brown. Pleurae dark brown. *Wings* unspotted and without long decumbent hairs; surface closely covered with minute upright spicules; fringe short; stronger hairs on costa scanty. Venation as shown in the figure (fig. 14); first cell

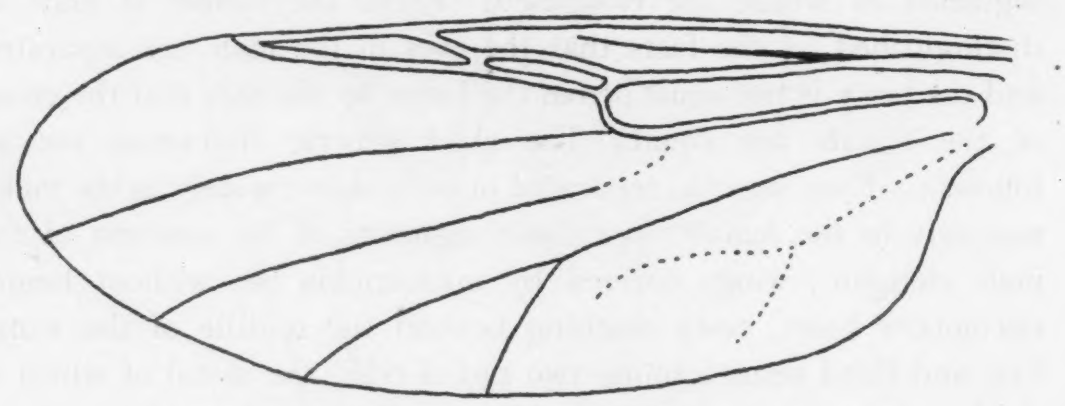

FIG. 14. *Schizodactylus telmatoscopus*, sp.n., venation of wing of male. (× 70 circa.)

rather large and long. Halteres with pale brown knobs. *Legs*: femora and tibiae dark brown; first four tarsal segments pale coloured with slightly infuscated apices, last segment entirely dark. Trochanters with small, paired, curved spines. Femora not unusually broad, bearing on all the legs two or three stout, short, dark spines on the under surface near the apex. First tarsal segment about twice the length of the second on all the legs; last segment rather elongated, fourth not cordiform. Regular rows of small spines are situated ventrally on the first tarsal segments of

the middle legs and on the first and second tarsal segments of the hind legs; those on the first tarsal segments of the hind legs arranged in a double row. Apically the fore tibiae bear a long, pale-coloured, ventral spine, the middle tibiae a strong, dark-coloured spine, and the hind tibiae the usual double row of bristles. First four tarsal segments of the middle and hind legs with a pair of strong, dark spines apically, those on the fourth segments being more slender. Claws about half the length of the fifth tarsal segment, equal, simple, but with bifid ends; empodium rudimentary. *Abdomen* dark brown; venter slightly paler than the dorsum.

Hypopygium (fig. 15). Dark brown, well chitinised, relatively rather small. *Ninth segment*: tergite bearing few bristles, terminating distally on each side in a large hairy process bearing two relatively long bristles; sternite deeply excavated in the middle,

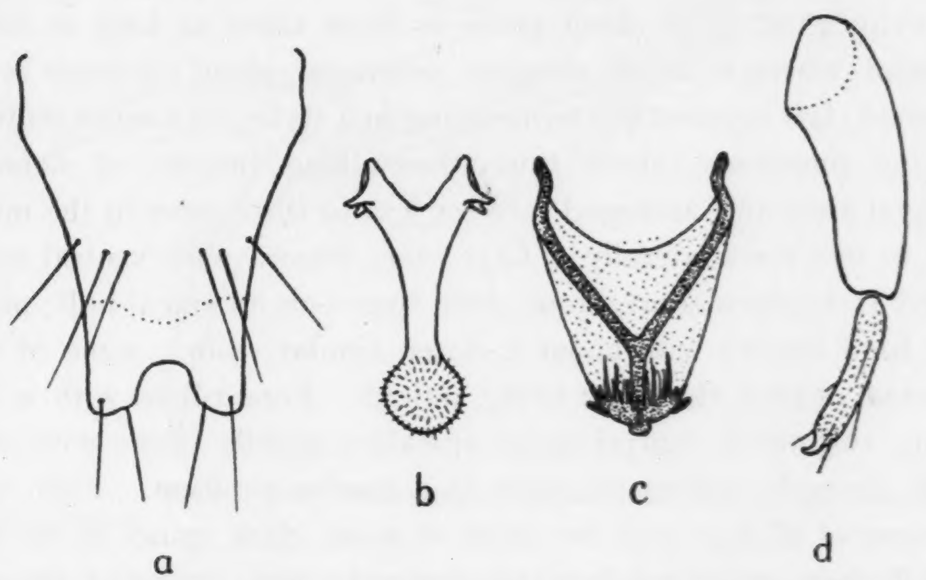

Fig. 15. *Schizodactylus telmatoscopus*, sp.n., male hypopygium. *a*—dorsal view; *b, c and d*, ventral views. *a*—ninth tergite (small hairs not shown); *b*—harpes; *c*—aedoeagus; *d*—forceps (hair on side piece not shown). (× 150 circa.)

reduced to a narrow band of chitin. *Forceps*: side-pieces rather narrow, hairs not very long; claspers short, bearing at the distal end a small claw. *Harpes* fused into a median, strongly chitinised rod; proximal extremity bifurcated, each half with two processes; distal end expanded, rounded in ventral view but slightly spoon-shaped in lateral view, not highly chitinised, closely covered with minute hairs. *Aedoeagus*: Y-shaped, chitinised portion with lateral flaps of spiculated membrane on each side; distal end broad, with a small

spine at each side, and an irregularly chitinised fringe extending anteriorly; ventral wall between the limbs of the Y well chitinised, spiculated; membrane connecting the aedoeagus with the ninth sternite with a very few spicules at its distal border only.

FEMALE. The following morphological details of the female were made out in a specimen extracted from a pupa of the same sample, and which was apparently identical with those of the males. *Head*: eyes narrowly separated. Palpi longer than in the male, and segments relatively more slender; first segment small, second, third, and fifth longer and sub-equal, fourth somewhat shorter. Third palpal segment not inflated, without a definite sensory cup but with a slight anterior depression from which arise a number of sensory hairs, the extremities of which are only slightly dilated. *Antennae*: first segment bearing four hairs; torus somewhat pyriform and bearing a considerable number of short hairs; segments four to ten cylindrical, from about twice to three times as long as broad; segments eleven to fifteen elongate, sub-equal, about six times as long as broad; last segment not terminating in a stylet. *Thorax*: scutellum bearing numerous (about thirty-three) long bristles of somewhat unequal sizes and arranged more or less in three rows in the middle and in two rows laterally. *Legs*: fore femora with ventral row of twelve to fourteen short, stout, dark spines on its apical half; middle and hind femora with about a dozen similar spines, some of those situated nearest the apex being paired. Fore tibiae with a long, feebly chitinised, ventral spine apically; middle tibiae with short, dark, strongly chitinised spine in a similar position. Fifth tarsal segment of all legs with two pairs of stout, dark spines at the base; middle legs, and hind legs less distinctly, with a pair of somewhat similar spines at the apex of the first, second, and third tarsal segments. Double row of small spines on the first tarsal segment of the hind legs complete. Claws long, equal, almost as long as the fifth tarsal segment; those of the fore legs (fig. 16) with a rather large basal barb, which is not present on the other legs. Empodium rudimentary. *Abdomen*: spermathecae two, highly chitinised, oval; length 123μ to 133μ, greatest breadth 106μ to 121μ; only the very commencement (about 4μ) of the duct chitinised.

PUPA. Length about 4 mm. to 5 mm. Form similar to that of *Culicoides*, and, therefore, the description will be given on the same

lines as was done in the case of that Genus. The pupa is very dark coloured and highly chitinised, especially at the anterior part of the cephalo-thorax. *Respiratory trumpets* short, broad, and straight, arising from rather depressed tubercles and without definite stalk; length about 260μ, breadth in the middle about 65μ. The main tracheal trunk is very broad, straight, without lateral branches, at its distal end terminating in a semi-circular, fan-like arrangement of about fifteen short processes. *Cephalo-thorax.* Anterior marginal tubercle small, bearing a small bristle; anterior dorsal small, bearing a small bristle; dorso-lateral small, bearing two bristles; ventro-lateral small, bearing two or three short bristles; ventro-median obsolete, represented by two small hairs. Dorsal tubercles

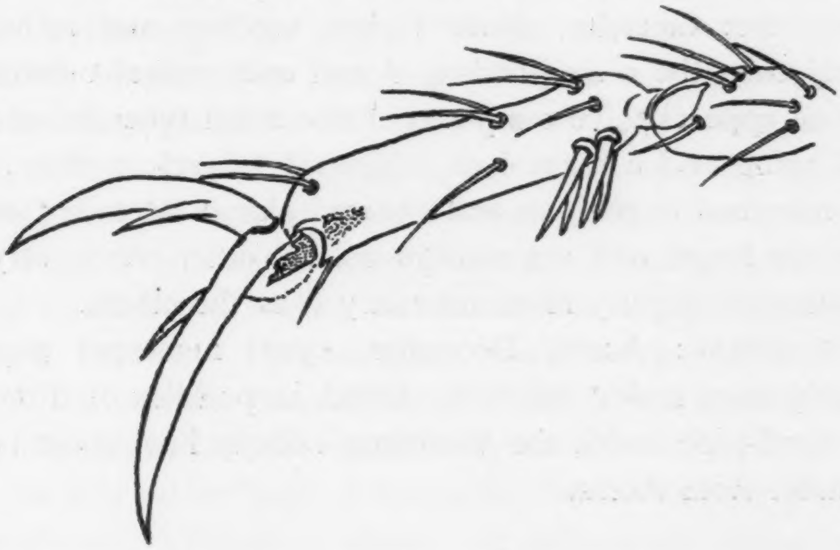

FIG. 16. *Schizodactylus telmatoscopus*, sp.n., fifth tarsal segment and claws of foreleg of female.

practically obsolete: anterior represented by two bristles slightly separated from one another; posterior by a single bristle; and lateral by a bristle and a socket-like mark, apparently unarmed, a little external to it. The dorsum is highly chitinised and very dark, the integument closely covered by small dark granulations; there is a transverse band of dark patches on the anterior third similar to that seen on many species of the Genus *Dasyhelea.* The postero-dorsal tubercle apparently obsolete. The posterior margin of the dorsum is rounded, not prolonged backwards as a median process. *Abdomen*: first segment, very short, second, long and broad; third to eighth, sub-equal but tapering towards the posterior extremity,

almost square; ninth, short and small, with two short, sharply-pointed, divergent terminal processes. There are a few dark spots on the integument of most of the segments: dorsally, two sub-lateral anterior, two admedian central, and a central a little farther back; ventrally, two sub-lateral anterior, and a central somewhat heart-shaped spot between and behind them. The tubercles are all small, and bear only small spines or hairs. The following may be distinguished on each side of a typical segment. Dorsal tubercles: antero-submarginal, two, very small, the outer being situated almost laterally; postero-marginal, three, small, the inner one situated posterior to the inner antero-submarginal tubercle, the outer two contiguous, situated almost laterally. Lateral tubercles: antero-submarginal, single, very small; postero-marginal, two, rather larger than the other tubercles, situated close together and rather more anteriorly than the corresponding dorsal and ventral tubercles, the dorsal one appears to be composed of two fused tubercles and bears a small spine and a short hair. Ventral tubercles: three, small, postero-marginal in position and situated almost laterally; the inner two are the larger and are contiguous, the outer one is very small and is situated slightly more anteriorly than the others.

GOLD COAST: Accra, December, 1920; numerous pupae (of which only two, males, hatched), found in puddles of dirty water near a stand-pipe beside the Weshiang railway line, about two and a half miles from Accra.

Genus *SPHAEROMIAS* (Stephens), Curtis.

This genus includes those midges in which the eyes are bare, the wings bare except for minute, point-like hairs visible only with a microscope, third vein extending beyond the middle of the wing, second radial cell longer than the first, fourth vein forking almost under the cross-vein, femora unarmed and not swollen, fourth tarsal segments cordiform, fifth not swollen, empodium absent or rudimentary. It is apparently the same as the Genus *Johannsenomyia* erected by Malloch to include those species, which he had previously included in *Johanniseniella*, 'which have the media furcate proximad to the cross-vein.' One male of a single species of this genus was obtained near Accra.

Sphaeromias litoraurea, sp. nov.

MEASUREMENTS.

Length of body (one male)	1·6 mm.
Length of wing	1·2 mm.
Greatest breadth of wing	0·4 mm.

Head dark brown. Eyes widely separated, smooth. Clypeus and proboscis dark brown. Palpi dark brown: all five palpal segments short, but the third and the fifth rather longer than the fourth; third palpal segment slightly longer than broad, not inflated, with a few long, knob-ended sensory hairs on its inner side anteriorly which arise from a very shallow depression. *Antennae* dark brown: plume poorly developed, composed of relatively few and short hairs which are not arranged in distinct whorls; segments four to eleven progressively longer, from once and a half to a little over twice as long as broad; segment twelve about three times as long as broad; segments thirteen to fifteen longer, sub-equal, bearing only short hairs, the terminal segment tapering distally but not ending in a stylet. *Thorax* uniformly dark brown. Pleurae dark brown. Scutellum dark brown, bearing two admedian, two sub-median, and two lateral bristles. Post-scutellum dark brown. *Wings* clear, unspotted, the anterior veins brownish. Third vein extending some distance beyond the middle of the wing; two radial cells, both well formed, the first rather large, rectangular, the second longer than the first; fourth vein bifurcated, sessile, the bifurcation taking place a little proximal to the cross-vein. Wing surface covered by microtrichia but otherwise bare, without decumbent hairs. Halteres with dark brown knobs. *Legs* almost uniformly brown, but with indications of darker knee-spots and with the tarsal segments slightly infuscated. Trochanters with usual pair of stout, curved spines. Femora unarmed, not swollen. First tarsal segments much longer than second, fourth cordiform. First and second tarsal segments of hind legs with conspicuous ventro-lateral row of small spines. Tibiae of fore legs with a long ventral spine at the apex. Tibiae and first two tarsal segments of middle legs with small, paired, apical spines; first tarsal segment bears also several similar spines on its ventral border. Claws equal, about half the length of the fifth tarsal segment, bifid. Empodium absent. *Abdomen* dark brown.

Hypopygium (fig. 17). *Ninth segment*: sternite reduced to a narrow strip of chitin; tergite not highly chitinised, bearing apparently only two long bristles dorsally near its middle, the chitinisation of the tergite interrupted a little posterior to them, the posterior margin with a short hairy process on each side, the ventral surface thickly covered by short hairs, the lobe-like processes well developed, covered by short hairs, and bearing one or two longer bristles. *Forceps*: side-pieces rather long and narrow; claspers short, terminating in strong, pointed hooks, basal two-thirds hairy.

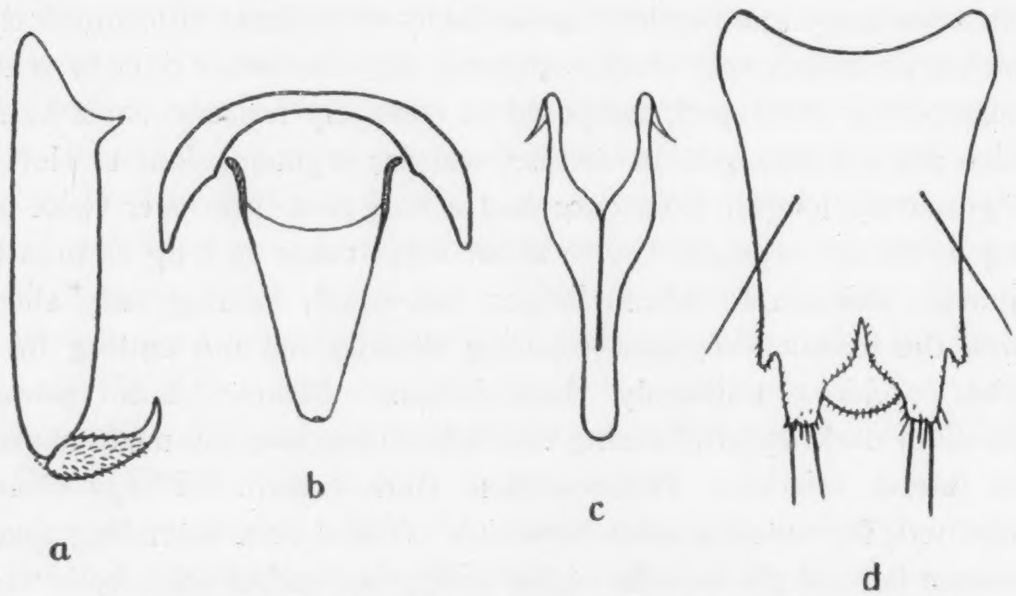

Fig. 17. *Sphaeromias litoraurea*, sp.n., outlines of male hypopygium. *a*, *b*, and *c*—ventral views; *d*—dorsal view. *a*—forceps (bristles and hairs of side-piece not shown); *b*—aedoeagus; *c*—harpes; *d*—ninth tergite (small surface hairs not shown).

Harpes dark brown, highly chitinised, with a double dorso-ventral curve; distal extremities fused to form a blunt, rather broad, process. *Aedoeagus* conical, proximal portions of the limbs narrow and highly chitinised, distal portions less highly chitinised; distal extremity broad, with a slight ventral lip; ventral wall slightly chitinised to about the level of the middles of the highly chitinised portions of the limbs; membrane joining the aedoeagus to the ninth sternite not spiculated.

Gold Coast: Odorkor, a small village near Accra, November, 1920; one male, obtained from a drain situated near a stand-pipe. Weshiang, near Accra, June, 1921; one male, reared from plants of the water-weed *Pistia stratiotes*, taken from the river Densu.

Genus *BEZZIA*, Kieff.

The chief characters of this genus, according to Kieffer (1919), are—eyes glabrous, the last three or four antennal segments in the male elongated, the wings bare or covered by microscopic setae, the first and third veins not united by a cross-vein and forming a single cell, the bifurcation of the fourth vein scarcely proximal to or under the cross-vein, the femora on the fore legs at least armed with one or more ventral spines in both sexes, the fourth tarsal segment cordiform, the fifth unarmed in both sexes, and the claws small, not half the length of the fifth tarsal segment, simple in both sexes, or sometimes with a small median tooth in the female. Up to the present we have not collected at Accra any specimens referable to this genus, but we have received from Lagos a single female of one species, and of this a description is given here.

Bezzia foyi, sp. n.

MEASUREMENTS.

Length of body (one female)	2·1 mm.
Length of wing	1·4 mm.
Greatest breadth of wing	0·5 mm.

Head dark brown, clothed with rather short dark brown hairs. Eyes smooth, narrowly separated. Clypeus, proboscis and palpi dark brown. Mouth-parts well developed, mandibles particularly highly chitinised, and bearing strong teeth on their inner edges. First palpal segment small, second short and broad, third, fourth, and fifth sub-equal, about twice as long as broad; the third segment scarcely at all inflated and without a sensory cup, but bearing a patch of sensory hairs on its inner aspect; the fifth segment pyriform, its distal end broad and rounded, bearing a few rather long hairs. *Antennae* dark brown, the terminal segments rather paler at their bases; hairs short, dark brown. First segment small; torus sub-spherical, bearing numerous short hairs; third rather longer than the fourth, with a short stem; segments four to ten oval, slightly constricted at their bases, their lengths varying from once and a half to twice the greatest breadth; segments eleven to fifteen elongate, about three or four times as long as broad, the last segment the longest and ending in a conical tip without a stylet. *Thorax*

uniformly very dark brown, clothed with short, dark brown hairs, and bearing above the wing bases a few longer, strong hairs. Pleurae dark brown. Scutellum dark brown, not so dark as the dorsum; bearing two lateral and two centro-marginal bristles and very numerous short hairs. Post-scutellum dark brown. *Wings* clear, slightly infuscated near the anterior borders, the stronger veins brownish. Venation as shown in the figure (fig. 18 *a*). The costa does not extend as far towards the tip of the wing as in the female of *Probezzia pistiae* (p. 365); the fork of the fourth vein under the cross-vein. The surface of the wing covered by microtrichia and devoid of longer decumbent hairs; fringe very short on the apical third of the wing. Halteres with pale brown stems and dark brown knobs; knobs bearing a few short hairs. *Legs* dark brown, conspicuously banded. Femora dark brown, especially those of the

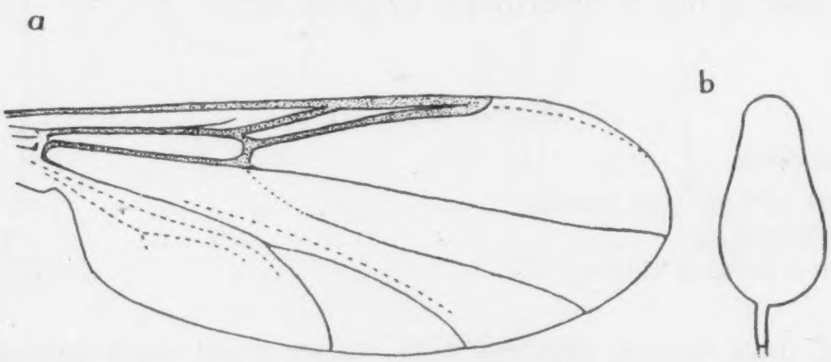

FIG. 18. *Bezzia foyi*, sp.n. *a*—venation of wing of female (× 50 circa.); *b*—spermatheca (× 210 circa.)

hind legs, slightly paler basally, and in the case of the fore and middle legs with a narrow pale band near the apex; knees dark brown; tibiae dark brown, with a narrow pale band near the base, and a less distinct, pale, sub-apical band; tarsi paler, last two segments infuscated. Femora not swollen; fore femora armed with two short, dark, ventral spines on its apical third, middle and hind femora unarmed. Tibiae unarmed, not swollen. First tarsal segment about twice as long as the second on the fore legs, relatively longer on the middle and hind legs; bulbous hairs conspicuous on the hind tarsus, forming two rows on the first and second segments, and one on the third, on the middle legs are single rows of similar hairs on the first and second segments. Fourth tarsal segment cordiform; fifth unarmed. Claws simple, equal, short, less than one-half the length of the fifth tarsal segment. Empodium

rudimentary. *Abdomen* dark brown, venter paler than the dorsum, scantily clothed with short dark brown hairs. Spermathecae two, highly chitinised, unequal, oval or egg-shaped and slightly constricted sub-apically (fig. 18 *b*); lengths about 103μ and 84μ in the single female examined, and greatest breadths 53μ and 49μ respectively; the duct narrow (about 4μ), and chitinised for some distance (about 25μ).

NIGERIA (Southern provinces): Lagos, July, 1921 (Dr. H. Andrew Foy); a single female taken in the evening upon the white lining of a lamp-shade. We have pleasure in dedicating this species to the collector, Dr. H. Andrew Foy, to whom we are also indebted for numerous other specimens of *Ceratopogoninae* from Lagos.

Genus *PROBEZZIA*, Kieff.

The chief generic characters of *Probezzia*, according to Kieffer (1919), are—eyes glabrous, last four antennal segments in the male elongated, wings bare or covered with microscopic setae, first and third veins separated for their entire length, bifurcation of the fourth vein scarcely proximal to or under the cross-vein, femora unarmed, fourth tarsal segment cordiform, fifth unarmed in both sexes, and claws small, about one-third the length of the fifth tarsal segment, equal and simple in both sexes, or with a small median tooth in the female. The two species which we have assigned to this genus differ slightly in two respects from the above description, namely, in having only the last three antennal segments definitely elongated, the twelfth segment being but slightly longer than the eleventh, and the fourth tarsal segment short and broad but not definitely cordiform. These differences are very slight, or may even depend on the manner of interpretation of the terms elongated and cordiform.

Both the species described here were reared from plants of the water lettuce *Pistia stratiotes*, but we were successful in procuring for examination the early stages of the first species only. The larvae are slender, almost white, eel-like organisms similar to those of *Culicoides*, but larger and with relatively longer and narrower heads. They resemble the figure of the larva of *Palpomyia longipennis*

given by Malloch (1915). They appear normally to inhabit the basal portions of the roots of the *Pistia* plants, and were reared to the adult stage from plants taken from the water and brought, or sent through the post, to the laboratory, and subsequently kept merely moist. They are, however, capable of leading an aquatic existence, and move very rapidly in water, swimming about in a manner similar to the larvae of *Culicoides*. At the posterior end of the body are long, stout hairs, which are an aid to progression. The pupae are similar in form to those of *Culicoides*. They are able to survive in water, but when placed in it quickly make for the side and wriggle themselves above the surface. In the latter situation they remain practically sedentary if undisturbed. The duration of the larval stage was not determined, that of the pupal stage was two to four days.

Probezzia pistiae, sp. n.

Measurements.	Male.	Female.
Length of body	1·6 mm.	2·5 mm.
Length of wing	1·1 mm.	1·9 mm.
Greatest breadth of wing	0·4 mm.	0·6 mm.

The male is a much smaller, and much darker brown insect, than the female. *Head*: occiput dark brown, with brown hairs. Eyes glabrous, separated in both sexes. Clypeus and proboscis brown, with brown hairs. Palpi dark brown, rather slender; the first segment short, segments two, three and five sub-equal, about twice as long as broad, the fourth segment rather shorter; third segment not inflated, without a sensory cup but with a few sensory hairs situated distally on its inner side. *Mouth-parts* somewhat similar to those of midges of the Genus *Prionognathus*. Labium soft and hairy. Labrum rather strongly chitinised, the proximal two-thirds broad, the distal third tapering, fringed with delicate hair-like processes. Hypo-pharynx broad, tapering distally to a rounded apex, and fringed. Mandibles (fig. 21 *d*), in the female, similar to those of *P. marmoratus*, and similarly situated, but without teeth and with only a few delicate hair-like processes on the outer edge; the teeth on the inner edge are seven, large and strong, and proximal to them is a row of delicate hair-like processes; in the male, mandibles smaller, less highly chitinised and without strong teeth, but with about five delicate hair-like processes on the inner side.

Maxillae rudimentary. *Antennae*: dark brown, the last five segments in the female, and the last three in the male, darker than the rest. First segment small, bearing a few short hairs in the female. Torus yellowish-brown in the female, dark brown in the male; bearing a few short hairs. Flagellum segments sub-cylindrical: in the female, segments four to ten from twice to nearly two and a half times as long as broad, segments eleven to fifteen elongate, from nearly five to seven times as long as broad, the fifteenth segment being the longest and ending bluntly; in the male, the twelfth segment about two and a half times as long as broad, the last three segments elongate, from three to five times as long as

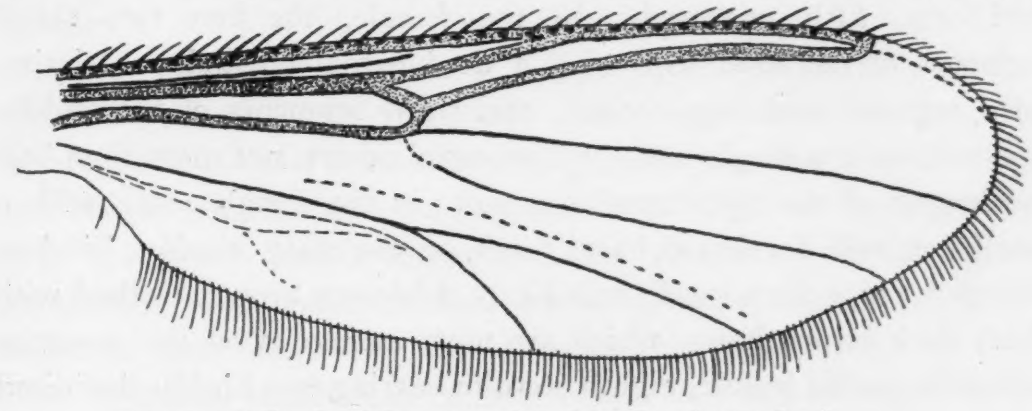

FIG. 19. *Probezzia pistiae*, sp.n., wing of female. (× 50 circa.)

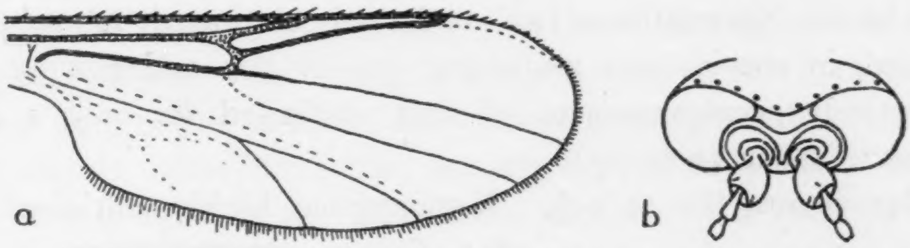

FIG. 20. *a—Probezzia pistiae*, sp.n., wing of male. (× 50 circa); *b—Probezzia stephensi*, sp.n., head of male. (× 60 circa.)

broad, the fifteenth segment being the longest and ending bluntly. Hairs short and scanty in the female; plume of the male poorly developed. *Thorax*: dorsum uniformly dark or darkish brown, clothed with short dark brown hairs and bearing laterally and posteriorly a few dark brown bristles. Pleurae darkish brown. Scutellum darkish brown, bearing a transverse row of six to eight bristles, and in the female numerous scattered short hairs; in the male are usually only six bristles, and the hairs are more scanty. Post-scutellum dark brown, without a pit. *Wings* unspotted. Venation as shown in the figures (figs. 19 and 20 *a*); costa in the

female extending further towards the tip of the wing than in the male. Surface of the wing closely covered with microtrichia; no macrotrichia present. Halteres pale brown, with dark brown knobs. *Legs* almost uniformly infuscated in the male; in the female, more or less banded, femora with a dark band before the apex, tibiae with a dark apical band and a dark band a little beyond the base, distal ends of first four tarsal segments and whole of fifth infuscated. Femora not inflated and without strong spines. Tibiae moderately hairy; fore and middle legs with a dark apical spine. Tarsus with first segment more than twice as long as the second, fourth short and broad, almost (especially in the male) but not definitely cordiform, fifth unarmed. In the female, the first two tarsal segments of the hind legs with a double row of 'bulbous' hairs, third segment and first, second, and third segments of the middle legs with only a single row. Claws equal, short, not more than half the length of the fifth tarsal segment; in the female, each with a small but well developed basal tooth, in the male, smaller, bifid at the tip. Empodium small, hair-like. *Abdomen* brown, clothed with short dark brown hairs, which are most numerous on the posterior segments; in the female, eighth sternite bearing two highly chitinised plates, one on each side of the vulva, clothed distally with numerous short hairs. Spermathecae two, moderately chitinised, sub-spherical, unequal, in one instance measuring 57μ by 50μ and 46μ by 40μ, respectively; commencement of duct chitinised for only a short distance (about 4μ to 7μ).

HYPOPYGIUM (fig. 21 *a-c*). Hypopygium highly chitinised and

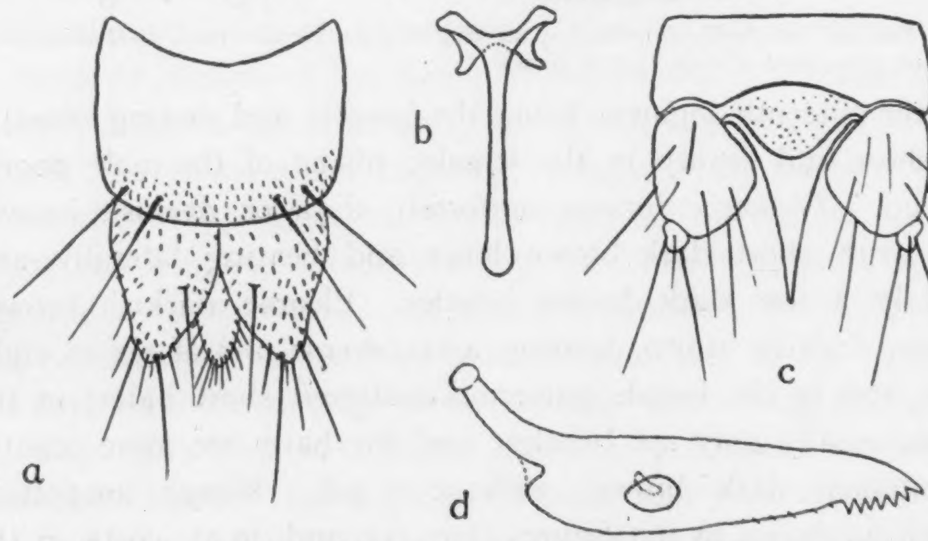

FIG. 21. *Probezzia pistiae*, sp.n. *a* to *c*—male hypopygium. *a*—ninth tergite; *b*—harpes; *c*—forceps and aedoeagus. *d*—mandible of female.

dark brown, rotated so that the forceps lie dorsally.* *Ninth segment*: tergite short, bearing at its posterior end two large, hairy, lateral lobes, between which the spiculated lining membrane of the tergite projects as a blunt process; sternite deep, slightly excavated in the middle. *Forceps*: side-pieces short and broad, about as broad as long, tapering slightly distally; claspers reduced to a small knob bearing a few long hairs. *Harpes* highly chitinised, fused in the middle line to form a stout chitinised rod, with a rounded, somewhat expanded distal extremity. *Aedoeagus* highly chitinised, tapering gradually to a narrow distal extremity; membrane joining the ventral wall of the aedoeagus to the ninth sternite studded with spicules.

PUPA. Length, female, about 3 mm., male, considerably smaller, about 2·7 mm. Well chitinised; male very much darker than female. *Respiratory trumpets* usually bent posteriorly, rather short and broad, length about 0·2 mm., ratio of length to breadth about 7 to 1, smooth and without knob-like processes, the distal end infuscated. The main tracheal trunk is broad, devoid of lateral branches, and terminates in a number (about eighteen) of short, blunt processes which lead to the surface and are arranged in the form of an inverted U. *Cephalo-thorax* of the usual form, but the separation of cephalic and thoracic portions is ill-defined. Anterior marginal tubercle very small, bearing a long bristle; above the highest part of the antennal case (the beginning of the flagellum part) are two socket-like marks, apparently unarmed; a little further back, and in front of the base of the trumpet, is a small tubercle bearing a minute spine; anterior dorso-median tubercle very small, bearing two small sockets, the inner unarmed, the outer bearing a short, spine-like hair, dorso-lateral situated very close to the base of the trumpet, rounded and irregular in form, bearing a long and a shorter hair and an apparently unarmed socket; ventro-lateral ill-defined, bearing a short hair and an unarmed socket; ventro-median represented by two moderately long hairs. Dorsal tubercles much reduced: anterior double, each half bearing a moderately long hair, lateral bearing a similar hair, posterior bearing a rather smaller one. Anterior to the dorsal tubercles is a transverse row of

* It will be convenient, however, for descriptive purposes to continue to refer to the surface on which lies the tergite as the dorsal, and to that on which lie the sternite and the aedoeagus as the ventral.

highly chitinised rugae, and posterior and external to the lateral tubercle is an unarmed socket. Postero-dorsal tubercle obsolete. Posterior margin of dorsum rounded, not extended backwards as a median process. *Abdomen*: first segment small and narrow, second large and broad, the others decreasing progressively in breadth towards the apex. Integument spiculated, especially in the male, and with pigmented areas similar to those of *Stilobezzia spirogyrae*. Anal segment with acutely pointed, slightly divergent, dark-tipped processes. Dorsal tubercles: antero-submarginal, small, situated close together and almost contiguous, each bearing a hair, the outermost the larger; postero-marginal, four, the inner small, bearing a minute hair, the next merely an apparently unarmed socket, the outer two larger, contiguous, each bearing a hair. Ventro-lateral tubercles: all arising from a central projection of the segment; antero-submarginal, small, bearing a hair, and a little dorsal and slightly posterior to this tubercle an apparently unarmed socket; postero-marginal, two, well developed, the ventral bearing a hair, the dorsal double and bearing two hairs. Ventral tubercles: postero-marginal, three, almost contiguous, the inner bearing a short hair, the other two longer hairs.

LARVA. The larva is eel-like and slender, pale coloured or nearly white; length 7 mm. to 9 mm., greatest breadth about 0·2 mm. to 0·3 mm. *Head* yellowish-brown, long and narrow, length about 0·4 mm., greatest breadth about 0·1 mm. Eyes black, bilobed or reniform, situated laterally a little anterior to the middle of the head. Antennae and palpi small. Hairs quite small, and some apparently unarmed tubercles also present: on the dorsal surface, one pair anterior admedian situated about the level of the mandibles, two pairs (the more anterior with a divided hair) and a pair of small, apparently unarmed, tubercles anterior dorso-lateral situated at about the level of the comb-like part of the hypopharyngeal sclerite, one pair of apparently unarmed tubercles central dorso-lateral, two pairs posterior dorso-lateral, and two pairs bearing small spines posterior admedian at the extreme posterior end of the head; on each lateral surface, one anterior, two about the level of the eye, and a small tubercle, apparently unarmed, a little more posteriorly; on the ventral surface, two pairs anterior admedian, and one pair central ventro-lateral. Mental plate with a strong, pointed,

central tooth, and two more delicate teeth on each side. Hypopharynx not very strongly chitinised, the posterior sclerite comb-like, bearing about a dozen pointed teeth. Mandibles large and highly chitinised, base expanded, distal portion a powerful hook. *Body* cylindrical, composed of twelve elongated segments each bearing a few minute hairs. On the distal end of the anal segment are fourteen stronger hairs arranged as follows: dorsally and ventrally two pairs of long, stout, dark hairs about half the length of the anal segment, and two shorter hairs; laterally, on each side a single short hair; these hairs are usually turned anteriorly, and in life appear to be of assistance in progression. Anal gills of the usual form, rather short, being about one quarter the length of the anal segment, deeply cleft into two pointed processes.

GOLD COAST: Oblogo, near Accra, December, 1920, to June, 1921, numerous specimens reared from plants of the water lettuce (*Pistia stratiotes*), taken from a swamp and from the river Densu (Pl. XXI, fig. 1). The larvae, while quite capable of leading an aquatic existence, appeared normally to frequent the roots of this plant, and were frequently reared to the adult stage in plants kept merely moist.

Probezzia stephensi, sp. n.

This insect, of which at present we possess only a single male, resembles *Probezzia pistiae*, and, indeed, was originally included among some examples of that species in our collections on account of its almost identical colour markings. Subsequently certain morphological differences were observed, particularly in the hypopygium, which warrant its separation as a distinct species. Only the chief differences between this species and *P. pistiae* are here given.

MEASUREMENTS.

Length of body (one male)	1·7 mm.
Length of wing	1·0 mm.
Greatest breadth of wing	0·4 mm.

Head (fig. 20 b) facets of eyes very widely separated (by about 105μ) dorsally; anterior median angle of the occiput broad and obtuse. *Thorax* with rather fewer hairs on the dorsum, and some

of them larger than those in *P. pistiae*; scutellum bearing two submedian and two lateral bristles, and a few (about a dozen) short hairs. *Legs*: hind legs with a single row of 'bulbous' hairs on the first tarsal segments only. Claws with terminal fork deeper. *Abdomen* bearing shorter and more scanty hairs.

Hypopygium (fig. 22). *Ninth segment*: sternite reduced to a narrow strip of chitin; tergite short, tapering, bearing only two large bristles which are situated one on each side near the posterior margin, continued posteriorly as two large processes, bearing hairs and a few bristles, which are separated from each other in the middle, and with a large, hairy, lobe-like process on its under surface. *Forceps*:

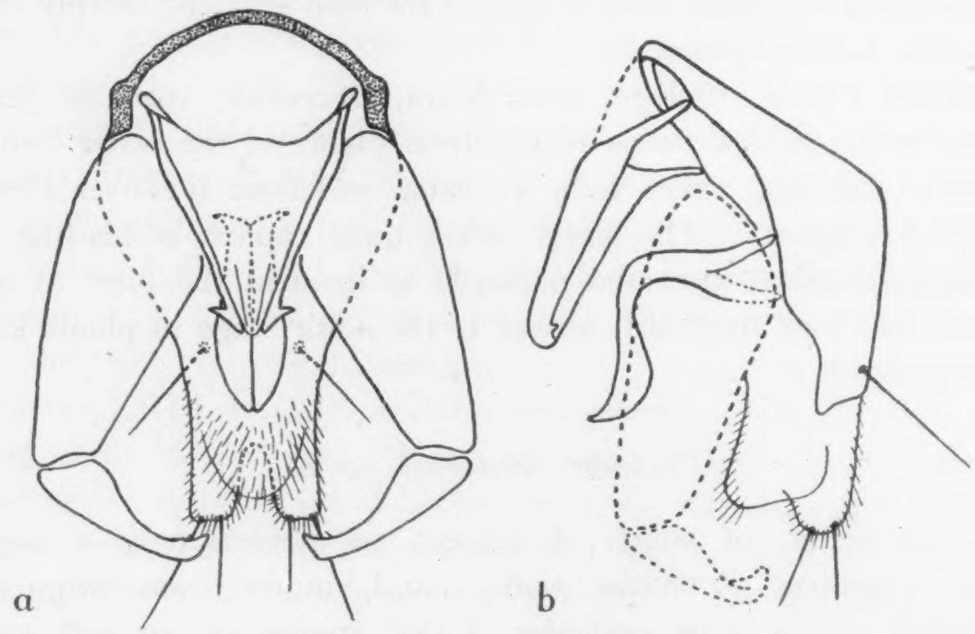

Fig. 22. *Probezzia stephensi*, sp.n., outlines of male hypopygium. *a*—ventral view; *b*—lateral view. (× 250 circa.)

side-pieces of usual form, moderately hairy; claspers of usual form, rather short (about half the length of the side-pieces), broad and without large hairs at the base, narrowing abruptly in the middle, and terminating in a somewhat spoon-like end. *Harpes* in lateral view bent in the middle at a right angle (see fig. 22 *b*), the distal halves somewhat beak-shaped; in dorso-ventral view the distal halves appear as two contiguous chitinous plates (see fig. 22 *a*). *Aedoeagus* broad, tapering, bearing on each side at the distal end a barb-like process; ventral wall chitinised almost to the base; membrane joining the aedoeagus to the ninth sternite devoid of spicules.

GOLD COAST: Oblogo, near Accra, March, 1921; reared from some plants of the water lettuce (*Pistia stratiotes*), taken from the river Densu. (Pl. XXI, fig. 1). We have much pleasure in dedicating this species to Dr. J. R. C. Stephens, to whom we are indebted for numerous interesting collections of biting midges from the Ilorin Province, Nigeria.

Genus *DICROBEZZIA*, Kieff.

The chief characters of this genus, which otherwise resembles *Bezzia*, according to Kieffer (1919), are—wings with the third vein reaching as near to the wing apex as the anterior branch of the fourth vein, femora unarmed, fourth tarsal segment cordiform, fifth tarsal segment in the female armed with several pairs of black 'batonnets,' in the male unarmed, and the claws in the female equal, bifid, the large branch two-thirds the length of the fifth tarsal segment, the small branch two-thirds the length of the large branch, in the male small and simple. We have referred the following species to this genus largely on account of the fact that the fifth tarsal segment in the female is armed with short, dark spines, but it should be pointed out that in other respects it does not entirely agree with the generic description given above. The differences are considerable, and would, perhaps, warrant the erection of a new genus.

The species closely resembles *Probezzia pistiae*, both as regards the general morphology of the adults, including the structure of the hypopygium of the male, and the characters of the pupa. In the following description, therefore, only the chief points of difference are noted.

Dicrobezzia nigritibialis, sp. n.

This insect, of which at present we possess only a single male and a single female, resembles closely *Probezzia pistiae*; the chief differences between it and the latter species are as follows:—

MEASUREMENTS.	Male.	Female
Length of body	2·3 mm.	2·7 mm.
Length of wing	1·7 mm.	2·2 mm.
Greatest breadth of wing	0·4 mm.	0·6 mm.

The female is darker than the male. *Head* very dark brown. Eyes separated in both sexes. Palpi in the male small, stumpy, tapering distally, all the segments very short; in the female, longer, as in *P. pistiae*. *Antennae*: torus almost black in both sexes: middle segments of the flagellum paler brown in the male, in the female, antenna entirely dark brown. *Thorax*: dorsum uniformly dark brown, almost black; hairs scanty. Pleurae very dark brown. Scutellum very dark brown, bearing in the male, two sub-median and two lateral bristles and a few short hairs; in the female four sub-median and two lateral bristles and numerous short hairs. *Wings* very delicate and with a white appearance, venation as in *P. pistiae*; micro-trichia extremely small and delicate. Halteres with pale yellowish-brown knobs, and darker stems. *Legs*: femora and tibiae very dark brown, first four tarsal segments pale, slightly infuscated at their apices, last tarsal segment entirely dark. Fourth tarsal segment in the male longer than in *P. pistiae*, cylindrical; in the female, shorter, especially on the fore legs. Claws of the male small, equal, bifid at the tips; those of the female large, each with a well developed basal tooth. Fifth tarsal segment in the female armed with numerous (twelve on the fore legs, fourteen on the middle and hind legs) strong, black spines; in the male unarmed. *Abdomen* dark brown, but not so dark as the thorax, and in the female paler proximally; in the female, eighth sternite bearing a few long, stout hairs on each side of the vulva. Spermathecae two, highly chitinised, sub-spherical and unequal (diameters about 76μ and 60μ, respectively); commencement of the duct chitinised for a short distance (about 10μ).

HYPOPYGIUM (fig. 23). Hypopygium very dark and highly chitinised. *Ninth segment*: sternite deep, excavated in the middle posteriorly; tergite not very highly chitinised, bearing at its posterior end two prominent, hairy, lobe-like processes, spiculated portion of its lining membrane prominent. *Forceps*: side-pieces moderately developed, hairs not very long, distal extremity conical; claspers obsolete. *Harpes* very densely chitinised, fused in the middle line, and projecting backwards as a process which does not expand at its end, but appears to be double; in dorso-ventral view the posterior projection appears to be straight but not all in the same focus, in lateral view it is seen to be bent sharply towards the

tergite near its distal end. *Aedoeagus*: form somewhat similar to that of *P. stephensi*, but more densely chitinised. Membrane joining the aedoeagus to the ninth sternite studded with spicules.

PUPA. The pupa is very highly chitinised, especially that of the female, and coarsely spiculated. Length, male 3·6 mm., female 4·3 mm. It differs chiefly from the pupa of *P. pistiae* in the following points. *Respiratory trumpets* not turned backwards, relatively shorter and broader than those of *P. pistiae*, terminal branches of the tracheal trunk only about ten in number. *Cephalothorax*: dorso-lateral tubercle bearing, apparently, only a single

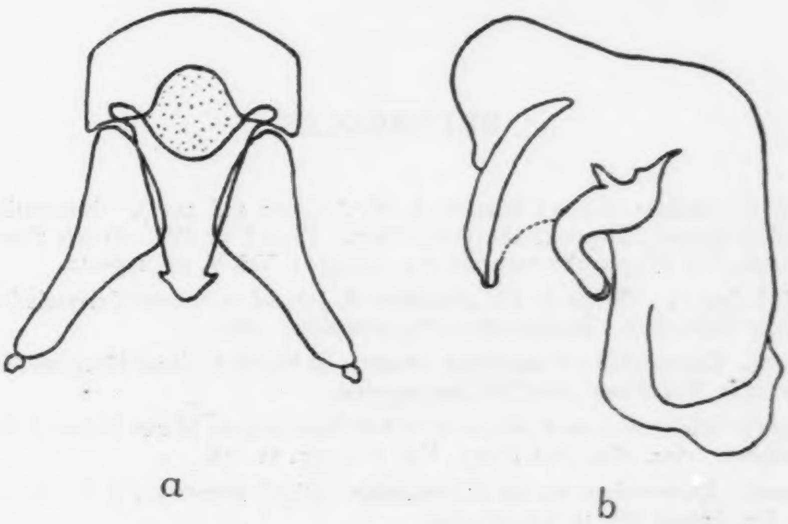

FIG. 23. *Dicrobezzia nigritibialis*, sp.n., outlines of male hypopygium. *a*—ventral view of forceps and aedoeagus; *b*—lateral view, middle focus showing harpes and aedoeagus. (× 190 circa).

hair, ventro-lateral composed of two small nipple-like processes, each armed with a stout hair; ventro-median apparently represented by a very minute hair. Dorsal tubercles very small: anterior double, the one part anterior to the other, each bearing a minute spine; lateral bearing a long hair; posterior bearing a minute spine. *Abdomen*: cuticle coarsely shagreened; large, dark, lateral macules at the anterior margin of the segments dorsally, in addition to the macules noted in *P. pistiae*. Anal segment: cases for forceps small and dark coloured. Dorsal tubercles: antero-submarginal not contiguous, a small hump with a socket-like mark posterior to the outer one; postero-marginal, three, the innermost small, bearing a small spine, the other two situated much more laterally, the inner rather large, bearing a short spine and having on its inner side an

unarmed socket, the outer small, bearing a hair. Ventro-lateral tubercles: antero-submarginal two, the dorsal one bearing a small spine, the ventral a hair; postero-marginal, two, well developed, each bearing a small spine. Ventral tubercles, three, practically contiguous, the inner bearing a short spine, the middle a long hair, and the outer a short hair.

GOLD COAST: Weshiang, near Accra, June 29th, 1921; two pupae found in a sample of the algae growing in one of the reservoirs of the Accra waterworks. We are indebted to Mr. R. Simmons for bringing these specimens to the laboratory.

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EXPLANATION OF PLATE XXI

Fig. 1. The river Densu at Oblogo, near Accra, showing the *Pistia* plants from which were reared the following midges:—*Culicoides distinctipennis*, *Dasyhelea inconspicuosa*, *Prionognathus pseudomaculipennis*, *Kempia ochrosoma*, *Probezzia pistiae*, and *P. stephensi*.

Fig. 2. Pool at Accra, from the marginal mud of which were reared the following midges:—*Culicoides austeni*, *C. distinctipennis*, *C. neavei*, *C. schultzei*, *C. similis*, *Dasyhelea fuscipleuris*, *D. inconspicuosa*, and *Stilobezzia spirogyrae*.

Fig. 1

Fig. 2

C. Tinling & Co., Ltd., Imp.

THE EFFECT OF SALINE SOLUTIONS AND SEA-WATER ON *STEGOMYIA FASCIATA*

BY

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(*Received for publication 24 August, 1921*)

Stegomyia fasciata is relatively intolerant of salt (NaCl). In some experiments carried out in 1915 it was found that the larvae died rapidly in 2 per cent. salt solution, that the gravid adult females were relucant to lay their eggs on this medium, and that if, *faute de mieux*, they did so the eggs were killed and did not even harden and darken. Moreover, it was found that normal eggs of *S. fasciata* placed in salt solution of about the same strength (2·3 per cent.) failed to produce living larvae. From these and some previous observations (1914) it was thought that sea-water might be found to be of service in the campaign against this mosquito.

More recently these experiments have been repeated at Accra actually using sea-water. It was found that undiluted sea-water killed the larvae in a few hours (two to four), and that when diluted with tap-water 50 per cent. (equal to about 1·6 per cent. NaCl) or over was fatal within twenty-four hours. As regards the influence on the gravid females and the action on the eggs, the results were similar to those obtained with salt solution as is shown by the two following experiments.

EXPERIMENT I. 20th May, 1919. *Stegomyia fasciata*, two females and one male in a jar containing sea-water. Females fed this day.

22nd May.	Male dead.
23rd ,,	No eggs. Females fed at 10 a.m.
25th ,,	4 p.m.—many eggs on the water, all white.
5th June.	No larvae have hatched.

EXPERIMENT II. 20th May, 1919. *Stegomyia fasciata*, one male and one female in a large jar containing sea-water in which stands a small beaker containing tap-water.

23rd May.	Female fed.
24th ,,	Male dead.
27th ,,	Many eggs on the tap-water, a few only on the sea-water: the latter are white.
1st June.	Many larvae in the beaker containing tap-water, none in the sea-water.

Sea-water, in fact, was found to act in a similar manner to a solution of common salt of equivalent strength.

An attempt was made to determine the highest percentage of salt that the larvae could tolerate. Such experiments are not easily devised because normally the larvae pupate after a few days, and it is therefore only possible to determine the percentages which prove fatal rapidly. Two series of experiments were carried out with the object of obtaining information on this point. In the one series larvae were used which were in the state of arrested development, to which reference has been made elsewhere (1915), and showed no inclination to pupate. Such larvae were placed in jars containing 100 c.c. or 50 c.c. of water to which each day 0·1 gm. of salt was added in a 10 per cent. solution; at the end of each experiment the amount of salt present in the medium was determined by titration. In four such experiments in which the strength of the saline medium was increased by 0·1 per cent. daily, the larvae did not survive more than 0·8, 0·9, 0·77, and 0·87 per cent. NaCl respectively. In four other experiments in which the strength of the saline medium was increased by 0·2 per cent. daily, they did not survive beyond 1·6, 1·8, 0·9, and 1·1 per cent. NaCl respectively. The results of these experiments were not quite satisfactory because in the control jars containing only tap-water some of the larvae died, showing that either the larvae in this state were delicate or that they were suffering from the lack of suitable or sufficient food.

It was thought, therefore, that a better practical test of the amount of salt tolerable to the larvae of *S. fasciata* would be obtained by starting a culture of these insects in a medium containing a low percentage of salt, allowing it to concentrate naturally by evaporation, and noting the point at which the larvae died. Such experiments it was thought would also show if the larvae were able to become habituated to high degrees of salinity.

An experiment was, therefore, started with a natural medium, rich in organic material, in a large jar on the sides of which were very many ripe eggs of *S. fasciata*. Sufficient common salt had been added to the medium to bring the percentage of NaCl up to 1·1. The jar, covered only by a piece of gauze, was then placed on the laboratory bench and allowed to concentrate gradually by natural evaporation. The larvae which hatched from the eggs developed

rapidly at first, then more slowly, and after about a fortnight appeared to be dying off. On the nineteenth day, when it was clear that they were rapidly diminishing in number, a small quantity of the medium was withdrawn for analysis. It was found to contain 1·3 per cent. NaCl. From this time onwards the larvae steadily dwindled, the last individual dying on the thirty-sixth day of the experiment, when the salinity of the medium was found to be 1·45 per cent. NaCl. During the experiment only a very few of the larvae pupated, and all that did so, excepting the first (which pupated on the ninth day, when the salinity was estimated to be 1·2 per cent.), died in the act. A second experiment on the same lines may be summarised as follows:—

1st Day. Salinity of medium equals 1·1 per cent. NaCl. Multitudes of little larvae which have just hatched.
8th „ Larvae fewer and not growing much.
16th „ Very few surviving larvae. No pupae yet.
18th „ Only two surviving larvae.
20th „ Last larva dead. Salinity of the medium found to be 1·38 per cent. NaCl. No pupae have appeared.

The four experiments of this sort (see table) that were carried out showed that the percentages of salt in the media at the times of the deaths of the last larvae were 1·45, 1·38, 1·45, and 1·45,

Number of days for which the experiment lasted	Percentage of NaCl in the medium at the beginning of the experiment	Percentage of NaCl in the medium at the end of the experiment, namely, when the last larva died	Number of pupae
36	1·1	1·45	1, and a few which died.
20	1·1	1·38	None.
24	1·0	1·45	None.
...	...	1·45	

respectively. The larvae had, of course, begun to die off some considerable time before this concentration was reached. Pupation was very seldom attempted, and was usually fatal. The experiments furnished no evidence that the larvae could be habituated to such degrees of salinity.

The inference from these experiments would appear to be that a 1·0 to 1·4 per cent. solution of common salt, or an equivalent strength of sea-water, would effectually prevent the larvae of this mosquito from developing to the adult stage. It would seem probable that sea-water, if used for such purposes as flushing drains and gutters, scowering market-places, etc., would kill both the larvae and the eggs of *S. fasciata*, and that even if puddles were left the adult females would be reluctant to deposit their eggs on them, but that if they did so the eggs would be killed immediately.

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THE PREVALENCE AND CHARACTER OF TUBERCULOSIS IN HONGKONG

BY

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III. THE MORBID ANATOMY AS MET WITH IN CASES AMONG CHILDREN

It is a well-known fact that the primary portal of entry of the bacilli in cases of tuberculosis and the mode of spread of the disease are by no means always easy to determine: in some instances, indeed, one can hardly do more than hazard a conjecture. When we remember that the bacilli may pass through a mucous membrane and even through the walls of vessels and circulate as foreign bodies without setting up any immediate injury, but only more remotely causing changes at some distant site where they finally settle, we must always be cautious against employing too freely the anatomical distribution of the lesions as found in the post-mortem room for the interpretation of their genetic relations. In some instances, again, none of the ordinarily described routes seem to explain the method of spread, as was indicated in some of those mentioned in a previous paper.

The extent and distribution of tuberculous lesions in an animal inoculated experimentally depend upon several factors, namely, the number and virulence of the bacilli, the resistance set up against infection by the inoculated animal, the seat of inoculation, and the time which has elapsed since infection. It was found as a result of several experiments in which the same dose of bacilli from the same source was inoculated at the same site (namely, subcutaneously into the left hind leg) into animals of the same species and as nearly as possible of the same weight, that in ten days the adjacent gland was involved; in ten to twenty days the left superficial and deep

inguinal and the sacro-lumbar glands, and also, perhaps, the spleen and the retro-hepatic glands. In another ten to fifteen days the liver, the lungs, the bronchial, suprascapular, and cervical glands on both sides showed involvement (Delépine).

Since in my series the respiratory portal of entry was that most frequently encountered, these cases will first be dealt with.

Albrecht, Ghon, and others hold that there is a special form of tuberculosis in children, consisting of a primary lung focus and resulting from the entrance of the bacilli by inhalation. This focus, they stated, was usually the size of a pea, but might be quite small and was rarely larger than a cherry.* In nearly three-fourths of the cases the focus was single. The focus is believed to arise 'in aggregations of lymphoid tissue in the neighbourhood of small bronchi.' Around this focus small tubercles are seen, and perhaps reactionary fibrous tissue. In the case of larger foci, hard, dry caseation is usual, and occasionally there is actual cavitation. As regards the situation of the focus, the order of frequency was: right upper, left upper, right lower, left lower, right middle, the first-named site being four times as common as the last.

An examination of the mediastinal glands showing involvement will, in many cases, enable one to predict the situation of the lung focus. The lymphatics, deep and superficial, discharge into the broncho-pulmonary glands situated between the branches of the main bronchi and at the hilus; those from the middle and lower portions of the lung into the inferior tracheo-bronchial at the bifurcation of the trachea; those from the upper into the superior tracheo-bronchial in the angle between the trachea and bronchus. There is also a chain of glands each side of the trachea, the para-tracheal glands. Infection across from one side to the other is frequently met with.

The original focus may open into a bronchus, and thus by inhalation a tuberculous broncho-pneumonia is set up; a like result would, of course, follow the perforation of a bronchus by an inherent gland. Again, there may be direct extension from a gland adherent to the pulmonary tissue, while, lastly, by communicating with a blood-vessel, miliary tuberculosis may ensue.

It used to be held that gland infection was primary and the lung condition secondary to it, but this would leave unexplained the

fact of apparently arbitrary selection of a site remote from the primary gland infection, while the intermediate tissue remained free from disease.

Canti examined the bodies of eighty-four children under ten years of age. Of these, there were thirty-three under one year, and sixteen (19·05 per cent.) showed tuberculous lesions. Of these sixteen, ten had foci in the lungs, the largest was the size of a cherry, the average that of a pea. In eight a single focus only was found; in one case two foci of practically the same age were seen, and one showed several; in this instance, however, one of the foci was cavernous and appeared older than the remainder. In the eight with a single focus, this was found three times in the left lower lobe, twice in the right upper, twice in the left upper, and once in the right middle. In other words, the findings in this series of Canti's agreed in the main with those of Ghon as affording evidence in favour of the common existence of pulmonary tuberculosis in children. The chief points to which attention is directed are the following, and, in discussing the series of cases considered here, I do not think one can improve upon the lines taken by Canti, and for purposes of comparison it is advisable to deal with the points in this order;—

1. The almost constant finding of a lung focus when tuberculous mediastinal glands are present, and the close relation of these glands to the lung focus.
2. The frequent singleness of the lung focus.
3. The constant finding of tuberculous mediastinal glands when a lung focus is present—a corollary of the first.
4. The almost constant absence of a lung focus when the portal of entry appears to be elsewhere.
5. The almost constant absence of evidence that the portal of entry may be elsewhere when a lung focus is present—a corollary of the last.

Work at the mortuary here has afforded me exceptional opportunities for studying these questions, the number of bodies to be examined is great, the proportion of children very high, and a few weeks' experience sufficed to drive home the fact that tuberculosis forms a large percentage of the causes of death.

The differences between the post-mortem findings in children

dying from tuberculosis and those in adults are considerable. Amongst the first three hundred consecutive cases with which this and the two previous papers are concerned there were two hundred and twenty-five under ten years of age. The remaining seventy-five are insufficient for a study of adult tuberculosis, so this paper will be restricted to dealing with the disease as it occurs in children here. The number (two hundred and twenty-five cases) will provide sufficient basis for argument as to whether the conditions of tuberculosis in the tropics, as exemplified at least in Hongkong, resemble those at home, and, if not, in what the differences consist. For purposes of discussion, it will be well to take the points in the above order.

1. *The almost constant finding of a lung focus when tuberculous mediastinal glands are present, and the close relation of these glands to the lung focus.*

The truth of this statement has been substantiated in the majority of the present series. In twenty-nine instances, however, caseous mediastinal glands were found without any focus being detected in the lungs. Eleven of these showed strong evidence of being primarily alimentary and the mediastinal glands may have become involved secondarily to the mesenteric, a condition the occurrence of which was proved by the experimental work of Calmette, Guérin and Breton (1907). They found that in guinea-pigs dying in two to four weeks after being fed on the bacilli the mesenteric glands (especially the superior deriving from the small intestine) were enlarged and inflamed, although no trace of any intestinal lesion could be determined. After six to seven weeks, these glands were caseous in greater or less degree and the lungs showed involvement by miliary tubercles with affection of the corresponding tracheo-bronchial glands. Furthermore, these glands, as shown in several of the cases detailed in this series, become caseous more rapidly than the pulmonary lesions preceding their involvement.

In one other of my series there was a tuberculous abscess of the sixth cervical vertebra discharging into the right pleural cavity, which might account for the involvement of the mediastinal glands without a focus in the lung. Putting these aside, there were still seventeen which did not conform to the statement relative to the

presence of a lung focus when mediastinal glands are found and the relation of the glands to the focus. Of these seventeen, there were fifteen which showed miliary tubercles in the lungs, occasionally in considerable numbers, but in twelve only a few; nevertheless, mediastinal glands on one or both sides were found enlarged and caseated. In none of them was any sign of tuberculosis found in the tonsils or cervical glands. Where the involvement of the lung with miliary tubercles is fairly extensive, it may be argued that the gland constituted the focus whence the lung became infected, but then we are still in the dark as to the source whence it became itself tuberculous.

Apropos of some of these cases, the remarks of Bushnell in the *Military Surgeon* (1918) may be recalled. He states that from a hilus infection the tubercle bacillus is described as travelling by the peribronchial lymph spaces in a direction opposite to that of the normal lymph flow to a region in the upper lobes where the lymph motion is most sluggish. This might be aided by a reversal of the lymph current, and such a reversal might in turn occur as the result of a block at the hilus. The tubercle bacilli travelling by these spaces to the parenchyma are resisted by the tissue cells and a type of peribronchial tuberculosis results. Caseation through the bronchus may take place, although peribronchial tuberculosis is more often of the 'closed' type, as is evidenced clinically by the frequency with which the bacilli are found in the sputum and the rarity of haemorrhages in such cases.

In two others the difficulty is increased by the fact that although the mediastinal glands were enlarged and caseous, in one case the tracheo-bronchial, in the other the paratracheal, forming adherent and caseous masses, there was no involvement of the lungs at all. In the former there were meningeal tubercles mostly at the base and along the sylvian fissures, whereas in the latter the only organs found affected were the kidneys, where at the base of a pyramid towards the lower pole of each were several minute tubercles focally arranged.

So much for instances in which caseated mediastinal glands were found without a corresponding focus in the lung. As regards the second point—the close relation of the affected glands to the lung focus—there were four cases in which the two did not

correspond, in other words, the expectation of localising the lung focus from the gland involved was falsified. In three the focus was in the left lung, as large as a haricot bean, and in one case there was a cavity as large as a filbert; in the fourth the focus was in the right lung. In each case there was a caseated gland, but on the opposite side. The related glands on the affected side were, in three, not involved at all, and in the fourth there was a little congestion only.

It is well known that communication between the glands from one side to the other may be free, and this may be offered as an explanation of the passage of infection from one side to the other; nevertheless, it is less likely that in children, in whom caseation of the mediastinal glands occurs early and readily, infection should pass to the opposite side and apparently miss those on the side affected. One example may be quoted briefly:—In a boy, three years of age, there was a sub-apical focus as large as a pea in the right lung and a few scattered miliary tubercles in both; the hilus glands were enlarged on both sides, but whereas on the right they showed merely a small caseous point on section, on the left the gland was completely caseated. This differs from the four previously mentioned in that there was a spot of caseation in the gland on the side of the focus, whereas in the others the related glands had apparently escaped altogether.

2. *The frequent singleness of the lung focus.*

Among the sixteen cases described by Canti there were eight with a single focus, while Ghon states that in 72·35 per cent. this is the case. Of the two hundred and twenty-five children under ten years of age among my series of three hundred cases, there were one hundred and thirty-seven showing focal conditions in the lungs. Of these, there were ninety-five in which the focus was single, *i.e.*, in 69·34 per cent.; in forty-two, or 30·66 per cent., there was more than one.

Ghon found that when only one lung focus was discovered the various lobes were involved in the following order of frequency:—Right upper 30·98 per cent., left upper 23·24 per cent., right lower 22·54 per cent., left lower 15·49 per cent., and right middle 7·75 per cent.

Of the ninety-five cases in my series in which only a single focus was found, the numbers in which each lobe was concerned were:—Right upper twenty-six, or 27·37 per cent.; right lower twenty-three, or 24·21 per cent.; left upper eighteen, or 18·95 per cent.; left lower fifteen, or 15·79 per cent.; right middle thirteen, or 13·68 per cent. The main differences, it will be seen, are that in his series the left upper and right lower were affected in about an equal number of times, the former slightly preponderating, whereas in mine these were reversed, and, secondly, in mine the proportion in which the right middle lobe was involved was much higher.

As regards those which contained more than one focus, there were thirty-two with two, five with three, and the same number with several. The following was the distribution in cases with two foci:—

Both in the upper lobe of the left lung	5
Both in the lower lobe of the right lung	5
Both in the lower lobe of the left lung	4
Both in the upper lobe of the right lung	3
One each in the lowest and middle lobes of the right lung ...	4
One each in the upper and lower lobes of the left lung ...	4
One each in the upper and middle lobes of the right lung ...	2
One each in the upper and lowest lobes of the right lung ...	2
One each in the upper lobe of each lung	2
One each in the lower lobe of each lung	1

Of the five instances in which three foci were found, in one case all were in the upper lobe of the right lung; in another all were in the lower lobe of the left. Of the remaining three, all were in the right lung, viz., one in the upper and two in the lower in two cases, and the reverse of this, two in the upper and one in the lower in one.

Finally, in the five cases in which there were more than three foci, the following was the distribution:—All in the left lower lobe in one; in another, three foci were present in the upper lobe of the left and one in the upper of the right; in a third, foci were present in all lobes except the right upper; in a fourth, in all except the left upper; in the fifth, in all except the left lower.

Taking all the cases in which foci were found in the lungs, *i.e.*, in one hundred and thirty-seven instances, the right upper lobe

was involved forty-two times, the right lower forty-one, the left upper thirty-two, the left lower twenty-eight, and the right middle twenty-two. Thus, whereas Ghon found that the left upper was that most frequently involved after the right upper, in my series these were reversed; the right upper and right lower were involved almost an equal number of times, whether we consider merely cases with a single focus or whether we have regard to all instances in which focal lesions were present.

3. *The constant finding of tuberculous mediastinal glands where a lung focus was present.*

In adult cases this has certainly not been my experience here, but it appears to hold good with nearly all cases in children. In twelve of this series, in spite of focal affection of the lung, and even of considerable advancement of the disease, there was no naked-eye involvement of mediastinal glands. In four of these the glands showed microscopically giant cells and a few bacilli. In three others, owing to the early age at which death occurred (twenty-two, twenty-four and twenty-nine days, respectively), although foci were present and the disease was of considerable extent in the lungs, an explanation of the absence of tuberculous affection of the corresponding mediastinal glands may be tendered by suggesting that death took place before there was time for gland involvement to arise. This hypothesis finds a certain measure of support from two others, each of seven weeks old, in whom there was a lung focus and the corresponding mediastinal gland was congested and slightly swollen, not macroscopically tuberculous, but on sections being made giant cell systems and bacilli were seen. On the other hand, the findings in two others appear to deprive this hypothesis of its value. In one of these, a child of three years, there was typical phthisis—tuberculous broncho-pneumonia with ulceration—and in the other, four years of age, the disease had been in existence long enough to produce caries of three vertebrae in addition to a lung focus and several caseating tubercles; nevertheless, no corresponding gland involvement was found.

4. *The almost constant absence of a lung focus when the portal of entry appeared to be elsewhere.*

This is a more difficult matter on which to pass an opinion out here, where the chances of infection by a double route, respiratory and alimentary, are so great. In a previous paper, when we were discussing cases in which the primary portal was uncertain, several of such were dealt with. To take these as instances for consideration as to the verity of the dictum of this section would be to beg the question. The statement would apply rather to places where one sees either respiratory or alimentary cases, or at least cases in which the primary portal is undoubtedly one or the other, not those in which the dual route is not only possible, but, as in many here, highly probable.

Apart from these, there were five in which a definite lung focus was present, although the primary portal of entry was probably, in fact, one might say certainly, not via the respiratory tract. In two there was a condition of tabes mesenterica, the glands in the abdomen being in aggregated caseous masses; in one of these cases, an infant of eight months, there was a focus the size of a pea in the right lung; in the other, a child of twelve months, a focus as large as a marble, also in the right lung. In two others, aged twenty months and four years respectively, there was extensive tuberculous enteritis with numerous ulcers and caseated mesenteric glands, and in the second marked tuberculous peritonitis also; in each of these there was also a lung focus. In the fifth, a girl of four years, there was caries of three vertebrae, and several tuberculous ulcers were present in the intestine; in the lower lobe of the right lung was a focus as large as a cobnut.

It is a difficult matter to discuss this question apart from the next, namely:—

5. *The almost constant absence of evidence that the portal of entry might be elsewhere when a lung focus was present.*

In the previous points, my findings have been to a great extent in agreement, but in this, if I understand it correctly, my experience is distinctly at variance.

Several of the cases reported in this series would find an explanation in a dual route of infection, whereas the statement above

would appear to rule out such an occurrence, not merely as a more or less simultaneous infection, but even after an interval. So it would seem to put forward the claim that, given a primary lung focus due to respiratory route infection, there is little, if any, likelihood of the intestine becoming affected unless secondarily to the pulmonary focus. This cannot be ascribed to an increased resistance or immunity owing to the presence of the lung tuberculosis, because it is a well-established fact that intestinal tuberculosis can arise from the swallowing of infected sputum.

One explanation which, however, in my opinion, savours rather of evading the difficulty than explaining it, would be to say that whenever a lung focus is present together with definite alimentary tuberculosis, the former was the primary site, and the intestinal, though perhaps more advanced, arose from the swallowing of the infected sputum. We may account for some of the cases in this way: the respiratory route gives rise to the lung focus primarily, the intestine becomes infected secondarily, and the lungs are again involved by miliary tubercles spreading via the lymphatics to the thoracic duct, and so to the pulmonary circulation. A considerable number in this series may be thus explained, and several have been mentioned in the previous paper.

In connection, however, with these points—the 'almost constant absence of a lung focus when the portal of entry appears to be elsewhere,' and the corollary of this, the 'almost constant absence of evidence that the portal of entry might be elsewhere when a lung focus was present'—there are twelve which did not appear to conform. There is no need to describe them all; two examples will suffice:—(i) A girl of four years with tuberculous caries of the spine. In the discussion on this case, it was stated: 'The spinal site was probably the oldest; from the number of ulcers in the intestine, from the fact of the large and the small both being involved, and from the mesenteric glands being in large caseous masses, the alimentary tract would appear to have been involved prior to the lung.' There was a sub-apical focus in the right lung the size of a cobnut, becoming caseous. (ii) A female infant of eight months; the mesenteric glands were in large caseous masses, whereas the mediastinal were not much enlarged and contained merely small caseating points. The tuberculous infection of the lung

was limited to the middle lobe of the right, in which there was a distinct focus the size of a pea.

It has been stated by MacCallum that in children one may find, instead of the apical lesion so common in adults, a caseous softening of bronchial lymphatic glands and erosion through a bronchus to produce wholesale tuberculosis of a lung, or a large section of it. Several of the cases in this series might be looked upon as examples of this; we must bear in mind, however, that, though this may explain generalised infection of part or even the whole of a lung, we still leave unaccounted for the source whence the gland became involved. In those instances in which we find a focal lesion, the subsequent more generalised condition in that lung, or part of it, may be ascribed to reinfection from the gland, which itself was due to the primary focal lesion. In cases where no focal lesion is found to which the mediastinal gland could be traceable, and especially in cases where both lungs are attacked by miliary or grey tubercles, the spread may have occurred by the blood-stream; if general, by the pulmonary circulation, if localised, either by a branch of this or of a bronchial artery. In one case, in which there was caries of the right side of the sixth cervical vertebra and pus discharging into the right pleural cavity, into a loculus shut off by pleural adhesions, the glands at the hilus and along the trachea were caseous and may have arisen secondarily to the lesion above, and the widespread miliary affection of the right lung may then have resulted by the method which MacCallum describes.

Passing on to the question of abdominal and alimentary tuberculosis, there is not much to be said in this paper dealing with the aspect of the morbid anatomy. As already stated, cases of isolated primary tuberculosis of the intestines, not uncommon at home, are comparatively rarely met with out here. In only four instances was the disease confined to the abdomen; three of these were infants, aged respectively ten, eighteen and twenty-two months, the fourth was a child of seven years. From the intestines with, or more often without, any local lesion, the bacilli are arrested for a time in the mesenteric glands and thence spread either by way of the lymphatics to the blood and so to the lungs (of this, several instances have occurred in this series, and have already received sufficient mention), or else by the portal blood to the liver. This has been

very rare in these cases. In fact, cases in which the liver was extensively involved have been few. The spleen in nearly all was more affected than the liver, and in two only was the liver infected and not the spleen. When tubercles were found in the liver, in the large majority of instances they were small, miliary to pin-head, and confined to the surface. The rarer forms of intestinal tuberculosis where the disease is localised to the region of the ileo-caecal valve to produce a mass of tuberculous cicatricial tissue constricting the lumen, I have met with once among these cases.

The following is worthy of mention while dealing with alimentary forms. The subject was a child of two years; there were tuberculous ulcers in the small intestine, and the mesenteric glands were enlarged and caseated. A tuberculous meningitis was the only other lesion detected; there were numerous pin-head tubercles at the base and a few on the vertex. The mode of extension in this case is obscure. One only evades the question by saying that it was probably metastatic by way of the blood-stream, analogous possibly to cerebral abscess in cases of haemorrhoids and in liver conditions.

The meninges and brain were found involved in a considerable number of cases, particularly the former, and usually as miliary tuberculosis affecting mostly the base and the Sylvian fissures. Definite focal masses in the brain or cerebellum were comparatively rare.

There were several cases in which the lungs and meninges were the only parts in which tubercles were found. In seven instances the meninges and one lung only were affected; in six of these it was the right lung which was attacked. In one other case, in addition to the lung and meningeal involvement, there was a tuberculous focus the size of a small marble in the right cerebellar hemisphere. In one case, a girl of eight years, the mediastinal glands and the meninges were the only parts found affected, there being no tubercles, either focal or miliary, in the lungs.

The mode of extension to produce the peculiarly limited distribution of tubercles in lungs and meninges is obscure, and is, perhaps, analogous to brain affections secondary to other pulmonary conditions, bronchiectasis, for example. There is not, as far as I am aware, any lymphatic connection between the lungs and the base of the brain, and if the extension occurred by way of the

blood-stream, why should the secondary infection be so limited? One would almost certainly expect to find signs in other organs.

I am also unable to suggest any significance for the fact that, in the combination of lungs and meninges, of the seven cases in which one lung only was affected, in six it was the right; and of the five cases in which both were involved, in three the right was more affected than the left. Again, in the case already referred to in which the mediastinal glands and meninges were tuberculous, but in which no signs were detected in the lungs, the glands were those of the right side only.

The combination of lungs, meninges and spleen was a little more common, fifteen of such being met with. In two of them only one lung was involved, in each case the right.

In this connection, it may be worth noting that the involvement of the spleen with miliary tubercles as the only abdominal viscus affected has not been very infrequent, and may find explanation, perhaps, if one regards the spleen as the meeting point of lymphatic and blood terminals. I may refer here to the observations of Dumas upon what he calls an unusual form of tuberculosis met with in Salonica amongst Senegalese and Arab troops. He noted that the mediastinal and peribronchial lymphatic systems were first affected, and later the pleura and pericardium. In the early stages the glands were merely enlarged, but later they suppurated or became caseous. At the onset there were no lesions of the parenchyma of the lung, and even later not the ulcerating and caseous form, only a few scattered tubercles. He considered that it was in the spleen that the lesions passed from the lymph to the blood stream. When the spleen was normal no tubercles were found in the lungs, but when the former was invaded the latter were also affected.

Examples of this in children, *i.e.*, cases in which the spleen is the only abdominal viscus involved and the connection referred to between this and the pulmonary findings seem to find support in some of the instances in this series. One may be given: a male child, three years of age, showed miliary tubercles scattered through both lungs, the spleen contained similar tubercles, as did also the meninges. The hilus and paratracheal glands on the right side were enlarged to the size of a cobnut and were caseous. Again, as was pointed out above, in the peculiar limitation at times to the

lungs and meninges, if haematogenous metastasis occurs, the first part to suffer is the meninges. In two other instances, however, the lungs were affected with small tubercles (no focus) and the hilus and paratracheal glands were caseated, but the spleen was not involved; in one of these blood infection was apparent, since the meninges revealed basal tubercles.

On nine occasions were focal tubercles found in the brain or cerebellum. The commonest site was the latter, for cerebellar were found in eight. Of these, the focus was present in four cases in the left hemisphere, in three in the right, and once in both. In this last there were four distinct foci, two in each lateral lobe; two others had a second, extra cerebellar, focus, namely, in the right cerebral hemisphere in one, in the left crus in the other. Finally, one subject, a female child of two and a half years, exhibited multiple foci: three distinct ones in the left lobe of the cerebellum, two in the left cerebral hemisphere, and one in the left hippocampus.

A striking feature of the tuberculous conditions as met with here is the rarity of bone, joint or skin affections. In this series there were five with tuberculous ulcers of the skin, four of these on the face and neck and one on the forearm. Not a single instance of tuberculous joint disease was encountered, and only three with bone lesions. In two of these there were caries of the lower dorsal and upper lumber vertebrae; a third had caries of the sixth cervical vertebra, and tuberculous disease also of the left tibia and both femora. A fourth had widespread tuberculous disease—lungs, liver, spleen, peritoneum and meninges—and extensive caries of the left mastoid, but there was no absolute proof that this last was due to tubercle.

Tuberculous cervical adenitis, so frequently met with at home, is a comparative rarity in the post-mortem room here. Of the whole series there were only twenty-eight instances, and in three of these the enlargement was very slight, so slight that there was not sufficient macroscopical evidence to determine its nature; on section, however, giant cells and tubercle bacilli were seen.

In one case there was almost universal involvement of the glands—cervical, submaxillary, supraclavicular, axillary, mediastinal, mesenteric and femoral—together with widespread pulmonary, intestinal, and some renal tuberculosis. This was a child of only

three years. Sections did not show any of the usual conditions characteristic of Hodgkin's disease. In contrast to this, may be incidentally mentioned a little girl of seven months, showing but one cervical gland enlarged, with very extensive tuberculous disease—lungs, pleura, mediastinal glands, mesentery, intestines, liver, spleen, kidneys, meninges.

Cases in which the genito-urinary tract has been involved have been comparatively few in my experience here. The majority of these showed a few miliary tubercles as emboli in the glomerular capillaries, consituting part of a general haemic infection. There were ten instances in which the kidneys were found focally affected in conjunction with widespread tuberculosis. One, a girl of three years of age, merits further mention on account of the peculiar distribution. The extensive alimentary infection—tuberculous ulceration of both large and small intestines, caseated, adherent mesenteric glands, extensive infection of the peritoneum—and the equal distribution of tubercles throughout both lungs would point to the alimentary canal as the primary portal of entry. The condition of the kidneys, however, does not support the idea of a haematogenous origin from entrance of the bacilli into the general circulation from the lungs. Each kidney showed a large focus in a similar situation at the lower pole, the size of a cobnut and caseous, most advanced at the margin between the cortex and a pyramid, and passing in as if later it would discharge into the pelvis. No indication of involvement of the ureters was detected. The foci gave the impression that they had arisen from affection of the tubules in course of excretion (as mentioned by Aschoff and Israel). The foci were each of them in a more advanced state than a few smaller, pin-head and miliary, tubercles in the cortical area of the right kidney, which had more likely arisen by haematogenous infection. The kidney foci appeared to be of considerably older standing than the pulmonary condition, and showed more advanced caseation than the mediastinal glands, but less than the mesenteric. There were no indications of an ascending infection from lower down the urinary tract. Other viscera, liver and spleen, showed sparse tubercles only, and these were, in the former at all events, confined to the peritoneal surface. Briefly, the age of the kidney condition appeared to be less than that of the alimentary but

more than that of the pulmonary, and the mode of involvement is obscure.

Two others are of sufficient interest to warrant brief mention:—(i) An infant of nine months, showing generalised tuberculosis—lungs, intestines, liver, spleen, kidney—and, in addition to miliary infection of the last, one calyx in the left was hollowed out and lined by tuberculous material; (ii) a girl of four years, with miliary tuberculosis of the lungs and of the liver surface, but the only focus found in the body was a caseated mass occupying practically the whole of a pyramid in the left kidney.

Finally, while speaking on the subject of genito-urinary affection, mention must be made of two cases of exceptional interest. Both exhibited extensive disease, lungs, meninges, intestines, peritoneum and ovaries. In one, a girl of four years, both ovaries were enlarged, and had become converted practically into caseated masses; this case has been described in a previous paper when discussing the primary portal of entry. In the other, an infant of only eight months, the Fallopian tubes were swollen and caseous on both sides, while the ovaries were in a condition similar to the last. In this case a possible (or, rather, probable) source was by contiguity from the tuberculous peritoneum, but in the former the tubes did not appear to be affected.

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ON THE GENUS *CYLICOSTOMUM**

BY

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Last year (1920 *a*, p. 268) I published an enumeration of the species of the genus *Cylicostomum*, and divided this genus into eight groups, of which three had been distinguished by Looss (1902, pp. 130-132). Since that time some new species have been described. Moreover, I think it necessary to modify somewhat the groups, so that I now divide the *Cylicostomum* species as follows :—

I. *Tetracanthum-coronatum* group.

The external leaf-crown is composed of eighteen to twenty-four elements; those of the internal leaf-crown are thin, triangular plates, the place of origin of the latter extending in a backward direction to some distance from the anterior margin of the mouth-capsule. Mouth-capsule rather short. Posterior extremity of the ♀ straight or slightly bent in a dorsal direction.

* Of late, some authors (Railliet, Travassos) use, instead of the name *Cylicostomum*, the genus-name *Trichonema*, which ought to be used according to the law of priority. In 1874, Cobbold (*Veterinarian*, Vol. XLVII, p. 85) described under the name *Trichonema arcuata* larvae of *Cylicostomum*. One year later (*Veterinarian*, Vol. XLVIII, p. 241) he established the fact that this *Trichonema* is the larva of '*Strongylus tetracanthus*,' the present genus *Cylicostomum* Railliet. As, however, the law of priority must be applied 'when any stage in the life-history is named before the adult,' and the name *Cylicostomum* (Railliet, *L' Écho Vétérin.*, Vol. XXXI, p. 40) is used in 1901 for the first time, *Trichonema* ought to be used.

It does not seem advisable to me in this, nor in the like cases, to adhere to the rules of zoological nomenclature, when, owing to this, a completely familiar name would be replaced by one still entirely unknown. Neither did I always adhere to the law of priority in my revision of the Trematodes, Cestodes and Nematodes of domestic animals, in the third edition of Sluiter and Swellengrebel, 'De dierlijke parasieten van den mensch en van onze huisdieren.'

1. *C. tetracanthum* (Looss), 1902, p. 124.
2. *C. labratum* (Looss), 1902, p. 124. H.*
3. *C. ornatum*, Kotlán, 1919, p. 10.
4. *C. labiatum* (Looss), 1902, p. 125.

4*a*. *C. labiatum* (Looss) var. *digitatum*, n. var. H.

5. *C. sagittatum*, Kotlán, 1920, p. 4.
6. *C. coronatum* (Looss), 1902, p. 125. H.

II. *Alveatum-catinatum* group.

The external leaf-crown consists of twenty to twenty-nine elements; those of the internal leaf-crown are similar to those of the first group. Posterior extremity of the ♀ strongly bent in a dorsal direction, with a swelling before the vulva, so that it reminds one of a human foot, seen laterally.

7. *C. alveatum* (Looss), 1902, p. 127.
8. *C. catinatum* (Looss), 1902, p. 128.

8*a*. *C. catinatum* (Looss), var. *litoraureum*, Yorke and Macfie, 1920, p. 166.

9. *C. pseudocatinatum*, Yorke and Macfie, 1919, p. 273. H.
10. *C. pateratum*, Yorke and Macfie, 1919*a*, p. 57 (= *C. cymatostomum*, Kotlán, 1919, p. 11). H.
11. *C. goldi*, Boulenger, 1917, p. 210. H.
12. *C. tridentatum*, Yorke and Macfie, 1920, p. 153.
13. *C. mettami*, Leiper, 1913, p. 460.

C. tridentatum and *C. goldi* are evidently closely allied species, as I found the three teeth of the oesophageal funnel of *C. tridentatum*, described by Yorke and Macfie, also in *C. goldi*. They are visible only in thoroughly transparent specimens with clean mouth-capsule.

It seems to me that *C. pseudocatinatum* must be considered a variety of *C. catinatum*. The former does not differ more from *C. catinatum* than does *C. catinatum* var. *litoraureum*, Yorke and Macfie. Both differ from *C. catinatum* in the appendages of the genital cone. Moreover, the appendages of *C. catinatum litoraureum* are more like those of *C. pseudocatinatum* than like those of the typical *catinatum* form. So when we consider *litoraureum* a variety as Yorke and Macfie do, this also applies to *pseudocatinatum*.

* The species occurring in Holland are marked H.

III. *Radiatum-elongatum* group.

Mouth-capsule with a hoop-like thickening at the posterior margin. Elements of the internal leaf-crown generally small and numerous, originating close to the anterior margin of the mouth-capsule. Posterior extremity of the ♀ straight, or slightly bent in a dorsal direction.

14. *C. radiatum* (Looss), 1902, p. 129.
15. *C. triramosum*, Yorke and Macfie, 1920, p. 175.
16. *C. elongatum* (Looss), 1902, p. 129. H.

16*a*. *C. elongatum* (Looss) var. *Kotláni*, Ihle, 1920, p. 269 (= *C. elongatum* var. *macrobursatum*, Kotlán, 1920, p. 6). H.

17. *C. insigne*, Boulenger, 1917, p. 207. H.
18. *C. zebrae*, Boulenger, 1920 *a*, p. 102.
19. *C. adersi*, Boulenger, 1920, p. 30.
20. *C. nassatum* (Looss), 1902, p. 128.

20*a*. *C. nassatum* (Looss) var. *parvum*, Yorke and Macfie (1918, p. 400). H.

21. *C. leptostomum*, Kotlán, 1920, p. 3. H.
22. *C. auriculatum* (Looss), 1902, p. 130.

The ♀ of the species last mentioned forms a transition to the *alveatum-catinatum* group by the form of its posterior extremity.

In this group I now also include *C. leptostomum*, Kotlán, a species about which Kotlán published a description in Hungarian only; the author was so kind, however, as to send me a German translation. *C. leptostomum* is closely allied to *C. nassatum*, from which it is distinguished by the posterior extremity of the ♀ being straight.

IV. *Calicatum* group.

Mouth-capsule mostly cylindrical or trapezium-shaped in optical section. Elements of the internal leaf-crown mostly short and implanted in the immediate neighbourhood of the anterior margin of the mouth-capsule. Posterior end of the ♀ mostly straight.

23. *C. calicatum* (Looss), 1902, p. 127. H.
24. *C. minutum*, Yorke and Macfie, 1918, p. 405 (= *C. calicatum* var. *minus*, Kotlán, 1920, p. 6). H.

25. *C. longibursatum*, Yorke and Macfie, 1918, p. 400 (= *C. calicatiforme*, Kotlán, 1919 *a*, p. 559 = *C. nanum*, Ihle, 1919, p. 720). H.
26. *C. hybridum*, Kotlán, 1920, p. 5.
27. *C. poculatum* (Looss), 1902, p. 126. H.

The last mentioned species differs considerably from *C. calicatum* (*e.g.*, in the bursa, which is closed all round and has a finely denticulated border) so that Looss (1902, p. 132) did not group them under one head.

V. *Euproctus-bicoronatum* group.

The external leaf-crown mostly consists of numerous slender elements; the elements of the internal leaf-crown are extremely large. The posterior extremity of the ♀ is straight.

28. *C. euproctus*, Boulenger, 1917, p. 204. H.
29. *C. bicoronatum* (Looss), 1902, p. 125. H.
30. *C. ihlei*, Kotlán, 1921, p. 300. H.
31. *C. ultrajectinum*, Ihle, 1920 *a*, p. 269; 1921, p. 372. H.

For the present, some heterogenous elements are taken together in this group, characterized by the possession of very large elements of the internal leaf-crown.

C. ihlei is closely allied to the genus *Poteriostomum* in structure of mouth-capsule and leaf-crowns. The fact, however, that the bursa copulatrix of this species shows the typical characteristics of *Cylicostomum* and differs from that of *Poteriostomum*, supports the opinion, shared by Yorke and Macfie (1920, p. 159), that *Poteriostomum* must be considered an independent genus contrary to Kotlán's view (1921, p. 299).

Formerly, I considered *C. ultrajectinum* to belong to the *radiatum-elongatum* group, with which it agrees in the thickened posterior margin of the mouth-capsule, from which it differs, however, in the size of the elements of the internal leaf-crown. It is, however, also considerably different from the other species of the *euproctus-bicoronatum* group in size and number of the elements of the external leaf-crown. Yorke and Macfie (1920, p. 162) expressed the opinion that *C. ultrajectinum* might belong to the genus

Poteriostomum. It has become evident, however (Ihle, 1921, p. 372), that the bursa copulatrix resembles that of the other *Cylicostomum* species in every respect, so that it is certain that this species belongs to the genus *Cylicostomum*.

VI. *Brevicapsulatum* group.

Mouth-capsule extremely short. Posterior extremity of the ♀ straight.

32. *C. brevicapsulatum*, Ihle, 1920, p. 562. H.

33. *C. prionodes*, Kotlán, 1921, p. 305.

These two species differ considerably, but they can be grouped together for the present.

VII. *Montgomeryi* group.

The dorsal and ventral walls of the mouth-capsule are much longer than the lateral walls.

34. *C. montgomeryi*, Boulenger, 1920 *a*, p. 104.

I will conclude by describing a new variety of *C. labiatum* (Looss), of which I found a small number of specimens in the large intestine of the horse in Holland.

Cylicostomum labiatum (Looss) var. *digitatum*, nov. var.

The new variety agrees in the main (mouth-collar, mouth-capsule) with the typical form.

♂ 7 to 8 mm., the immature ♀ 8 to $8\frac{3}{4}$ mm. long. Oesophagus 345 to 410μ long. The bursa copulatrix has a dorsal lobe, which varies in length and is mostly longer than in the typical form. The distance from the extremity of D^3* to the point of origin of the postero-external ray varies from 310μ to 380μ. The posterior part of the dermal collar shows the processes occurring in the typical form. The chief difference from the typical form is that the new variety shows finger-like processes on both sides of the posterior part of the genital cone, which are absent in the typical form. The number and form of these processes perhaps fluctuate. (In one case I counted three on each side.) The posterior extremity of the ♀ is like that of the typical form. The distance from the vulva to the

* The short stem which the dorsal rays have in common, I name D^0, the two main trunks D, the side branches, from before backwards, D^1, D^2, and D^3. In *Cylicostomum* D^3 forms the immediate continuation of D.

anus is smaller however (ca. 95μ) than in the typical form; the distance from the anus to the posterior extremity is 86μ to 110μ,

FIG. 1. *Cylicostomum labiatum* var. *digitatum*. Dorsal lobe of the bursa.

FIG. 2. *Cylicostomum labiatum* var. *digitatum*. Processes of the genital cone, lateral view.

FIG. 3. *Cylicostomum labiatum* var. *digitatum*. Posterior extremity of female, lateral view.

measured along the axis of the body. The conical end of the body is bent somewhat in a ventral direction.

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NOTES ON AUSTRALIAN CESTODES

BY

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INTRODUCTION

Whilst on the staff of the Australian Institute of Tropical Medicine, Townsville, a systematic examination was made of the large collection of Cestodes in the Museum. In addition to a considerable number of new species, the description of which will appear in subsequent papers, a number of previously described worms were found in new hosts.

I. PREVIOUSLY DESCRIBED CESTODES IN NEW HOSTS

Cittotaenia tachyglossi, Johnston, 1911
= *Cittotaenia*, sp. nov., Nicoll, 1914.

Nicoll (1914) recorded a new species of *Cittotaenia* from the Echidna, *Tachyglossus aculeatus*, Shaw, but without furnishing any description of it. Detailed re-examination of the same material proves it to be *Cittotaenia tachyglossi*, Johnston, but the dimensions are all somewhat greater than Johnston gives in his description, notwithstanding the fact that the worms are in an immature state similar to those from which the original description is given.

Diorchis flavescens (Krefft), Johnston, 1912.

The original description of this worm was published by Krefft (1873), who named it *Taenia flavescens*, but H. Johnston (1912)[1] re-examined Krefft's material and placed it in the genus *Diorchis*. Up to the present, this cestode has been found in *Anas superciliosa*, Gmel., the Black Duck; *Spatula rhynchotis*, Lath., the Blue-winged Shoveller; *Nettion castaneum*, Eyton, the Teal; and *Aythya*

australis, Gould, the White-eyed Duck. A few badly preserved fragments of apparently the same species have been found by the writer in material taken from *Dendryocygna arcuata*, Cuvier, the Whistling Duck.

Ophiotaenia longmani, Johnston, 1916.

Johnston (1916) originally described this species from the snake *Aspidotes ramsayi*, which was taken at Yarelba, Western Queensland. The same species was recently found by the writer in the intestine of *Python spilotes* var. *variegatus*, Gray, the Carpet Snake, which was killed near Townsville, North Queensland.

Ophiotaenia hylae, Johnston, 1912.

O. hylae was described by Johnston (1912)[2] with the frog, *Hyla aurea*, as its host, which was captured near Sydney, New South Wales. A scolex and several proglottides of this species were found in the intestine of *D. arcuata*, the Whistling Duck, which was shot near Townsville. This is strange, as the family *Proteocephalidae*, to which the above species belongs, has hitherto been recorded only in Amphibia, Reptilia, and the dog. The most probable explanation of this occurrence is, that the duck had swallowed a frog infected with the cestode, and the frog had been sufficiently digested to liberate it into the bird's intestine, without itself having undergone digestive changes up to the time the duck was shot.

Acanthotaenia gallardi, Johnston, 1911.

This cestode was originally described by Johnston (1911)[2] under the name *Proteocephalus gallardi*, and subsequently placed in the genus *Acanthotaenia*. On this occasion it was found in the intestine of *Pseudechis porphyriacus*, Shaw, the Black Snake. Since then it has been recorded by Johnston (1912)[3] as occurring in *Pseudechis australis*, Gray, the Northern Black Snake; *Notechis scutatus*, Peters, the Tiger Snake; and *Denisonia superba*, Gunth, the Copper-headed Snake. To this list of hosts the writer is now able to add *Dipsadomorphus fuscus*, Gray, the Brown Tree Snake,

a specimen of this snake harbouring this worm being killed near Townsville.

Moniezia alba, Blanchard, 1891.

Johnston has recorded the presence of this cestode in Australia in sheep in New South Wales, and the writer has recently obtained specimens of the same worm from a bullock, slaughtered in Townsville, and which came from near Hughenden, Western Queensland. This is the first record of this cestode in the above host in Australia.

Thysanosoma giardi, Stiles, 1893.

Johnston has noted the occurrence of this worm in sheep in New South Wales, but no note of its frequency and distribution has been given. Over a period of several months, the writer has had the opportunity of examining many worms taken from sheep in Townsville, and they all proved to be of this species. The sheep came from districts representing a wide area in Western Queensland, so it seems that it is widely distributed, and very common, but as far as could be ascertained from inquiries among pastoralists and butchers, it does not give rise to the serious pathological condition among sheep, that it does in other parts of the world.

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NOTES ON AUSTRALIAN CESTODES

BY

P. A. MAPLESTONE

(*Received for publication* 25 *November*, 1921)

II. *ANGULARIA AUSTRALIS*, sp. nov.

This cestode was found in considerable numbers in the intestine of a Stone Curlew (*Burhinus grallarius*, Lath.), shot near Townsville, North Queensland. It is probably rather rare, this being the only occasion on which it was encountered.

External Anatomy.

The worms are very small; the largest individual measured only about 3 mm. long; from its appearance the strobila was complete, but it had not quite reached full development. The number of proglottides in a chain varies between fourteen and twenty (fig. 1).

Fig. 1. *A. australis*. Appearance of worm as a whole. × 35.

On account of its small size, there are no macroscopic characters by which it may be recognised, so the following description of the appearance as a whole had to be determined under the low power of the microscope.

Head. The head bears a relatively long, thin rostellum, which was unfortunately broken off in most cases. From base to tip the rostellum is about 150μ to 200μ long, and it is about 14μ thick. It arises from a bulbous muscular structure, which lies in a deep fossa. It projects directly forwards as a long proboscis-like organ of uniform diameter, except at the tip where it expands into a globular enlargement, about twice the diameter of the stem (figs. 2 and 3).

FIG. 3. *A. australis.* Tip of rostellum, shewing disposition of hooks. × 225.

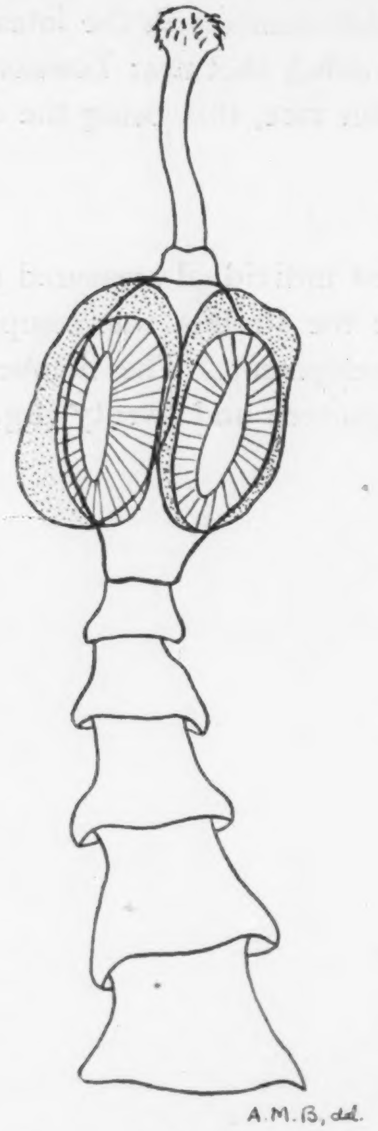

FIG. 2. *A. australis.* Head, and anterior parts of strobila. × 70.

FIG. 4. *A. australis.* Hooks. × 450.

The hooks, which measure about 25μ in length, are arranged in a zigzag line which forms four acute angles anteriorly and four acute angles posteriorly. Between an anterior and a posterior angle there are six or seven hooks. Thus, the total number of hooks is forty-eight or fifty-six. Their disposition and shape are shown in figs. 3 and 4.

The scolex is about as broad as it is long (250μ). The four suckers are relatively large oval structures, with their long axes antero-posterior; they are not exactly oval, being slightly narrower anteriorly. They measure about 130μ in length and 60μ in breadth, and their lips are provided with cuticular expansions, which project beyond the surface of the scolex (fig. 2).

Segments. For about the anterior half of the strobila the segments are quite narrow and rudimentary, the only change being a slight increase in length. But from about the mid-point of the strobila, the proglottides rapidly increase in size, and the reproductive organs reach complete maturity in the course of three or four segments. There are only three or four mature segments in each strobila, the genitalia undergoing a sudden atrophy when the uterus begins to develop, so that the two or three terminal segments contain, beside the uterus, only remnants of the reproductive organs (fig. 1).

The shape of individual segments is somewhat uncommon. Each one is like a truncated cone with the narrow end anterior, and the sides, which are concave in the anterior immature proglottides, become slightly convex in the posterior mature and gravid segments. The posterior surface of each proglottis is oval and slightly depressed in the centre, and into the middle of this depression the narrow anterior margin of the succeeding segment fits; the result of this is that the posterior borders project all round beyond the anterior portion of the following proglottis. There is no neck, but posteriorly the scolex narrows considerably to pass directly into the segmented chain. The first two or three proglottides are distinctly broader than long, and the next three or four increase in length but not in breadth, so that the sixth or seventh segment is longer than broad. Mature and gravid segments are slightly broader than long, their dimensions are about 160μ antero-posteriorly, 270μ across the anterior, and 460μ across the posterior borders respectively. But these dimensions are only approximate, on account of the rapid development of the worm. The terminal segment is nearly globular, with an invaginated pore at its posterior end.

INTERNAL ANATOMY.

Muscular system. The muscle layers are not conspicuous, and as sections were not cut, their detailed arrangement cannot be given.

Nervous system. The nervous system was not investigated.

Excretory system. The excretory canals, of which only a single one could be seen on each side, lie well towards the lateral borders, and pass ventral to the cirrus pouch and vagina.

Genitalia. Testes. The testes are arranged in the two lateral fields of the medulla with the female organs between them. They number about twenty in each segment, and there are usually one or two testes more on the aporal than on the poral side. They lie towards the posterior part of the segment on each side of the ovary (fig. 5). The cirrus pouch is relatively long and runs slightly

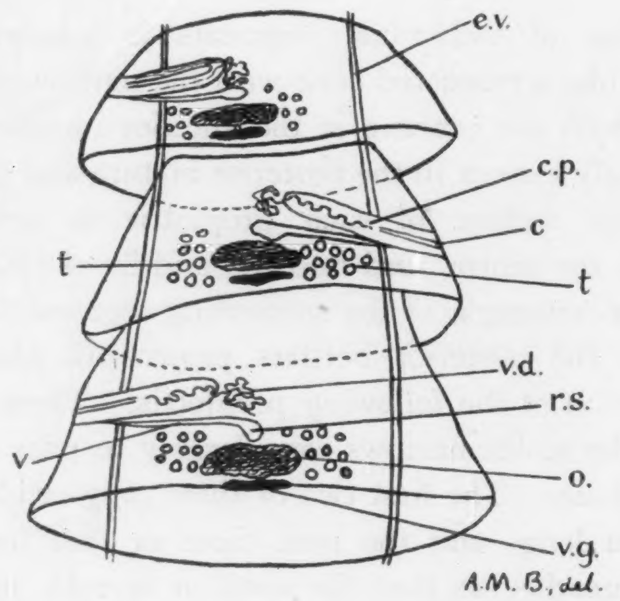

FIG. 5. *A. australis.* Mature segments. e.v., excretory vessel; c.p., cirrus pouch; c., cirrus; t., testes; v.d., vas deferens; r.s., receptaculum seminis; o., ovary; v.g., vitelline gland; v., vagina. × 90.

anteriorly towards the median line. The genital pores are situated about the centre of the lateral border, and are regularly alternating in most cases, but in one or two specimens there were three openings in succession on the same side, which was the greatest irregularity observed. There is no external seminal vesicle, but the vas deferens

is thrown into many coils in front of the ovary, before it enters the base of the cirrus pouch (fig. 5).

The cirrus is a long tubular structure, and in the one instance observed, where it was extruded, it measured 120μ long and 18μ thick. It is thickly covered with spines, and has a slightly swollen tip.

Ovary. The ovary lies in the median axis towards the posterior part of the proglottides. It is a compact, oval body; its long axis is transverse, measuring about 75μ (fig. 5).

Vitelline glands. The vitellarium is small and lies transversely behind the ovary, at the extreme posterior part of the segment; in full development it measures about 40μ long (fig. 5). The ovary and vitelline glands disappear very suddenly, being apparently in full development in one segment, and almost totally absent in the succeeding one.

Vagina. The vagina is a narrow tube running posterior to the cirrus pouch. It expands in front of the ovary into a small receptaculum seminis. Details of the shell gland could not be made out.

Uterus and eggs. The uterus was not fully developed, and its mature characters cannot be detailed, but it had the appearance of an irregular sac loosely packed with eggs, and is only visible in at most the three terminal segments. No free eggs were seen, consequently their size is not known.

DIAGNOSIS.

This interesting cestode closely resembles *Angularia beema*, Clerc (1906), but differs from the latter in the following points:—(1) Its smaller size (*A. beema* measures 45 mm. long), and (2) the presence of cuticular expansions on the suckers (absent in *A. beema*). It is, therefore, proposed to name this species *Angularia australis*.

The discovery of this cestode is of considerable interest, because the only other member of this genus hitherto described is *A. beema*, which, according to Lühe (1910), is very restricted in its distribution, only having been recorded from Russia.

Type specimens of this new species are in the Museum of the Liverpool School of Tropical Medicine.

The genus *Angularia*, Clerc (1906), resembles closely the genus

Gyrocoelia, Führmann (1899), so far as the head is concerned. Apparently, Linstow's genus *Brochocephalus* (1906) is a synonym of Führmann's *Gyrocoelia*. The points in which the two genera differ may be summarised as follows:—

Angularia.	*Gyrocoelia.*
Vagina present.	No vagina.
Testes 20 to 25.	Testes few.
Uterus without dorsal and ventral pores.	Uterus ring-like, opening by a pore dorsally and ventrally in gravid segments.

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NOTES ON ULCERATIVE GRANULOMA

BY

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The following notes on cases of Granuloma among Australian aborigines may be of interest, as they present some rather unusual features. The patients were treated at the Australian Institute of Tropical Medicine, Townsville.

CASE 1. Male, aet. about 50. The disease was first noticed about two years before admission to hospital; it began on the usual site, viz., the penis, and spread slowly and continuously. After this lesion had existed for some months, an ulcer appeared under the chin in the fold of the neck.

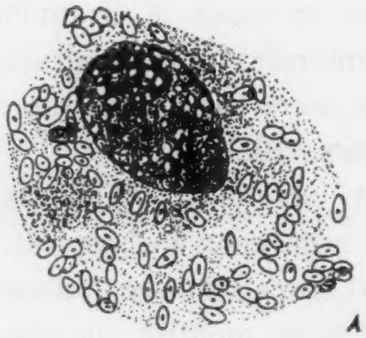
When first examined, the case presented the following appearance. The ulcer, which began on the penis, had spread until it reached from one anterior superior iliac spine to the other, and the penis itself had sloughed completely away, leaving the urethra to open in the middle of the ulcerated surface. The ulcer on the neck was about one and a half inches wide, and extended across under the chin, from one angle of the jaw to the other, the submaxillary lymphatic glands on both sides were considerably swollen, with consequent difficulty in opening the mouth.

The two lesions were similar in appearance, having clear-cut edges and shallow bases; they did not exhibit any granulomatous masses on their surfaces. Diagnosis in both ulcers was established by the discovery in them of the bodies described in Ulcerating Granuloma by Aragao and Vianna (1913).

This case presented the uncommon condition of a secondary focus of disease at a site distant from the primary, whither it had been most likely carried by the patient's hands.

CASE 2. Female, aet. 22. About three months prior to

admission to hospital the woman noticed a small nodule on the inner surface of the right upper lip; the nodule soon ulcerated, and the swelling and ulceration spread fairly rapidly. When first seen, there was a swelling of considerable size, which extended from the right upper lip, over about the anterior half of the inner side of the right cheek; there was more tumefaction and less ulceration than is generally seen in genital granuloma of the same duration. Smears made from scrapings of this growth were found to contain very numerous organisms, similar to those found in Case 1.



Typical infected large mononuclear cell from Case 2. × 1125.

There was no sign of a lesion in the genital region, so the case is apparently one of primary infection in a most unusual position.

CASES 3 and 4. These were both young native women. They both had small typical granulomatous lesions on the vulva, which they stated had only been present for two or three weeks. On examining the hospital records, it was found that both these women had been treated for similar conditions previously, and that one had been discharged fourteen months and the other fifteen months previously, both being apparently cured. A further striking fact, was that on the second occasion the lesions were on exactly the same site as on the first occasion, in both cases.

These two may be cases of reinfection after cure, but the similarity in time of the second manifestation of the disease, coupled with the fact that the lesions are both in exactly the same place as on the first occasion, makes it appear that they are recurrences after apparent cure.

TREATMENT

The routine treatment adopted in all cases was the application of a simple, non-irritant, antiseptic dressing to the lesions, and the intravenous administration of tartar emetic; 1 grain in 10 c.c. of normal saline twice weekly. Larger doses were unnecessary, improvement being observed after the first or second injection, and healing continued without signs of relapse during the course of treatment. The time required for complete disappearance of the lesions was proportionate to the extent of the ulceration present; *e.g.*, the first case cited above, with two large ulcers, took about three months to heal, whereas Case 2, with a small amount of ulceration, healed in about a month.

On account of the tendency of the disease to recur, five or six injections were given after the ulcer had quite healed.

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THE STRUCTURAL DIFFERENCES IN THE OVA OF *ANOPHELES MACULIPENNIS*, *A. BIFURCATUS* AND *A. PLUMBEUS*

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(*Received for publication* 19 *November*, 1921)

PLATE XXII

CONTENTS

INTRODUCTION

During investigations which entailed the breeding and rearing of the three species of British Anophelinae at the War Office Laboratory at Sandwich, Kent, in the summer of 1919, I noticed the quite different appearances between the eggs of *Anopheles maculipennis*, *A. bifurcatus*, and *A. plumbeus*, perceptible even to the unaided eye.

There are numerous illustrations of Anopheline ova in the English mosquito literature, but I have seen none indicating the markings on the dorsal surface of the ova of *A. maculipennis* which make it so easy a matter to identify the ova of this species from those of *A. bifurcatus*.

CERTAIN CHARACTERS OF MOSQUITO OVA

The eggs of mosquitoes, although showing much difference in form among the various species, nevertheless have certain characters that are uniform. Generally they are elongated, roughly cigar-shaped, or oval objects. The living elements in the eggs of insects are protected by three separate external coats: (1) a delicate innermost coat termed the vitelline membrane; (2) the hard, shell-like material termed the chorion; and (3) a thin outermost membrane which I shall refer to as the enveloping membrane.

All mosquito ova have the egg-shell proper (chorion) covered or partially covered with the delicate semi-transparent and water-proof enveloping membrane.

This membrane envelopes the egg but is not closely adherent to the shell, a layer of air often existing between the shell and membrane.* Eggs may be easily freed from the membrane by means of pressure with the point of a blunt needle, or by boiling the eggs in water for a moment or two. This membrane may either conform to the surface of the egg and lie so close to the egg-shell as to be only visible when special methods are adopted to demonstrate its presence, or it may, by being 'ballooned', form structures around the egg. Such structures are seen in the 'floats' of Anopheline ova.

The eggs of mosquitoes may be divided into two classes: (1) those that are laid on the water singly, and (2) those that are laid so that the eggs are adherent to each other and float in the form of a raft. In the case of the single eggs these float with their length parallel to the water-surface, and in the case of the raft-eggs they float in a vertical position.

In both classes the individual eggs often have a higher specific gravity than water, and consequently not being particularly buoyant, if submerged and the adherent air detached, they sink to the bottom. The membrane, owing to its water-proof properties, acts as an attachment to the water surface film, causing the egg to float as a dry sewing needle may float when it is placed so gently upon the water that the surface tension of the film is not overcome by the weight of the needle. Naturally, the substance of the egg weighs far less than a proportionate bulk of steel, and the stability of the

* According to Nicholson the membrane has a highly specialised attachment to the chorion.

egg at the surface is thus far greater even in those eggs unprovided with floats.

Nature has apparently recognised that in certain species a greater stability is needed than that afforded to single floating eggs and has developed the plan either of massing the eggs together to form a boat-shaped raft, or by ballooning the enveloping membrane in the single eggs to form the so-called 'floats' so commonly found among the ova of the Anophelinae. The 'floats,' however, do not act to any great extent as true floats giving buoyancy to the eggs, but support them on the surface film securely by presenting a larger area on which the weight of the eggs may be distributed against the surface tension. This fact may be demonstrated by forcibly submerging the eggs, when it will be found that they will either sink or very slowly rise to the surface, generally failing to regain their original position. Mosquito eggs that are laid in raft-formation are almost impossible to submerge without breaking up the raft form and detaching the eggs separately, on account of the air cells formed between the adjacent sides of the eggs. All mosquito eggs are submerged with difficulty, but submersion can be accomplished with the aid of a fine camel's hair brush by simply pressing on the eggs with the brush until each egg is driven below the water surface.

THE OVA OF *ANOPHELES MACULIPENNIS*

The average dimensions of the ova of *A. maculipennis* are, length 0·75 mm., breadth across the widest part of the float 0·27 mm. Eggs from different batches vary in their dimensions slightly, but the average variation is remarkably small. When the eggs are viewed from above while they are floating normally on the water it will be seen that the longitudinal outline of the dorsal surface is roughly cigar-shaped and the floats which lie on each side give the egg a slightly waisted appearance. The dorsal surface is comparatively flattened, while the lower or ventral surface of the egg is evenly rounded. One end of the egg is distinctly blunter and broader than the other. On the ventral side, just below the extremity of the broader end, the micropyle is situated, and it is from the broader end that the larva emerges. The floats are placed

on either side of the egg almost at the middle point, though they are actually a little nearer the more pointed end and extend for rather more than a third of the egg's total length.

The float membrane is finely striated transversely, but the striations do not indicate septa dividing the floats into compartments. The membrane which forms the float is superimposed upon the main enveloping membrane, being attached to the main envelope only along the ventro-lateral edges. This separate sheet of membrane which forms the float is ballooned outwards and curved upwards until it touches the dorso-lateral surface of the egg, to which, however, it is not adherent.

By submerging an egg it can be viewed from several aspects. Laid on its side it presents the outline shown in Plate XXII, fig. 1 (*b*), and upside down it has the outline shown in fig. 1 (*c*). It will be noticed that the under surface of the egg is somewhat boat-shaped and draughts progressively less towards the extremities of the egg; also that the enveloping membrane on the under surface of the egg shows hexagonal markings. The enveloping membrane embraces the egg completely except at the micropyle, where a small, round, black area is visible on the under surface of the blunter end of the egg. When the upper surface of the egg of *A. maculipennis* is examined it will be seen that the enveloping membrane spreads out in areas of unequal thickness, presenting, in consequence, dark and light markings as shown in fig. 1 (*a*). In these markings I find a very easy method of distinguishing the eggs of *A. maculipennis* from those of *A. bifurcatus* (compare figs. 1 (*a*) and 2 (*a*)).

The markings are easily seen with a hand lens × 6, and to the unaided eye give the eggs of *A. maculipennis* an ash-grey hue, whereas the eggs of *A. bifurcatus*, having no mottled markings on the dorsal surface, appear almost black in colour. The advantage of being able to distinguish the eggs of these two species from each other is considerable, especially when the species are being bred in the laboratory. Only one cage need be used, in which both species may be kept together; and oviposition may be allowed to take place in the same dish. The ova are then easily separated.

THE OVA OF *ANOPHELES BIFURCATUS*

Average length 0·61 mm.; breadth across the widest part of the float 0·19 mm. In general outline and structure the ova of *A. bifurcatus* closely resemble those of *A. maculipennis*, but the enveloping membrane which cradles the egg to the water line does not extend over the dorsal surface, and the dense black egg-shell is naked. The floats in this species overlap the lateral edges of the egg and give it a distinctly waisted appearance between the floats; moreover, the floats are often of unequal size, and asymmetrical. The two ends of the egg taper to a nearly equal degree, and the curvature of the ventral surface is greater than in the case of the eggs of *A. maculipennis*, causing the ends of the eggs to be more conspicuously upturned.

THE OVA OF *ANOPHELES PLUMBEUS*

The average measurements are, length 0·56 mm.; greatest breadth 0·17 mm. It has been found that to get *A. plumbeus* to tolerate laboratory conditions is far more difficult than with *A. maculipennis* and *A. bifurcatus*. It was only after numerous attempts that I finally succeeded in getting 'wild' specimens to oviposit in the laboratory. These specimens were captured in Epping Forest by exposing ourselves to attack and allowing the mosquitoes to feed. When replete, the mosquitoes were secured by placing a glass tube over them as they rested upon the skin of the arm. They were then transferred to the laboratory and placed in large insect cages containing an almost moisture-saturated atmosphere at a temperature of 30° C. Porcelain photographic developing dishes containing the water from beech tree-holes on which a few dead beech leaves floated were placed in the cages.

Four or five days afterwards the ova of this species were found floating on the water contained in one of the dishes. Owing to the colour of the tree-hole water and the form of the eggs they were exceedingly difficult to see, and when viewed as they floated on the deep brown-coloured water the 'floats' were quite invisible. The eggs were carefully transferred to clean tap-water, and were then seen to be particularly beautiful objects (Plate XXII, fig. 3).

Unlike the ova of *A. maculipennis* and *A. bifurcatus*, the ova of

A. plumbeus are somewhat like the ' diamonds ' of playing cards in outline, and are completely surrounded by the floats. The eggs are more pointed at the ends, both ends being alike, and bend slightly upwards. The central part of the upper surface is also raised, and the lower surface is evenly rounded.

It will readily be seen from the illustrations accompanying this paper that the ova of *A. maculipennis*, *A. bifurcatus*, and *A. plumbeus* are so conspicuously different from each other that the differences afford an effective means of identifying the species.

FACTS CONNECTED WITH OVIPOSITION

Anopheles maculipennis.

There is no difficulty in getting the females of this species to oviposit in the laboratory. Specimens captured in pigsties and placed in a large insect cage in the laboratory live well, and will lay several batches of eggs if a guinea-pig is placed in the cage overnight two days after the first and subsequent batches of eggs are laid. The eggs are always laid during the hours of darkness; most often, I think, in the early morning hours before sunrise. I have once obtained a batch of ova at 12 o'clock noon by placing the cage in a dark room.

The eggs when first laid are white, but they usually darken rapidly. Sometimes individual eggs in a batch will, however, remain white and fail to hatch, due, I think, to non-fertilisation. This condition is most readily seen in the ova of females that have been kept in the laboratory for some time and have laid numerous batches of eggs, and it is probably to be explained by a diminished supply of spermatozoa in the spermathecae.

The average batch of eggs laid by *A. maculipennis* in the laboratory has been found to be about one hundred and fifty.

Anopheles bifurcatus.

The eggs of this species are more difficult to obtain, for two reasons. Firstly, the adults are only numerous in many localities between the months of March and the end of May; and secondly, while I have found it easy to get oviposition to take place in the laboratory in the early months of the year, yet specimens captured

with difficulty after the end of May and placed under similar conditions cannot be induced to lay, even after they have fed and the ovarian eggs are fully developed. Differences in atmospheric temperature seem to account for this, as I find that as soon as the weather becomes cooler in the autumn and the mosquitoes become more numerous again, the females will readily oviposit. The average batch of eggs from *A. bifurcatus* in the laboratory has been found to be smaller than that of *A. maculipennis*, comprising about one hundred and twenty.

Anopheles plumbeus.

This species has been the most difficult from which to obtain ova. As mentioned previously, repeated attempts had to be made with fed specimens captured in Epping Forest before I was finally successful. So far, I have only managed to obtain three batches at different times from two females. In each case the batch was quite small, consisting of from fifteen to twenty-one ova.

With one of the females the second batch was laid a day later than the first, and this is probably a usual practice with the species to avoid overstocking any one breeding-place, since the majority of tree-holes have only a small water-holding capacity, and comparatively few larvae are to be found in each.

I have recently extended my observations to the ova of the British culicine mosquitoes, and find that in the ova of the species that I have so far examined there are remarkable specific differences sufficiently marked to be seen with the aid of a hand lens × 6, and to enable the identification of the species to be easily made. On this subject a further publication will be made shortly.

Probably owing to the difficulty in getting the majority of the species of mosquitoes to oviposit under laboratory conditions, there is a distinct scarcity of information on the specific differences in the ova. Most of the work on the biology of a species in the existing literature begins with descriptions of the larvae in the first instar, and ends with descriptions of the adult and its life history. The egg stage is, nevertheless, quite as important as any of the life stages—in many ways, from a practical point of view, a particularly important stage. Nuttall and Shipley (1901 and 1903), James and Liston (1911), and Howard, Dyar and Knab (1919) are noteworthy

in having given special attention to the description of certain Anopheline ova, but considering how numerous are the species of the *Culicidae*, it may be said that study and description of their ova has been almost neglected.

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Annals of Tropical medicine + Parasitology

ADDENDA

Vol. XV, p. 424, to *List of References* add:

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EXPLANATION OF PLATE XXII

Fig. 1. Ova of *Anopheles maculipennis:* (*a*) dorsal, (*b*) lateral, (*c*) ventral aspects of ova.

Fig. 2. Ova of *Anopheles bifurcatus:* (*a*) dorsal, (*b*) lateral, (*c*) ventral aspects of ova.

Fig. 3. Ova of *Anopheles plumbeus:* (*a*) dorsal, (*b*) lateral, (*c*) ventral aspects of ova.

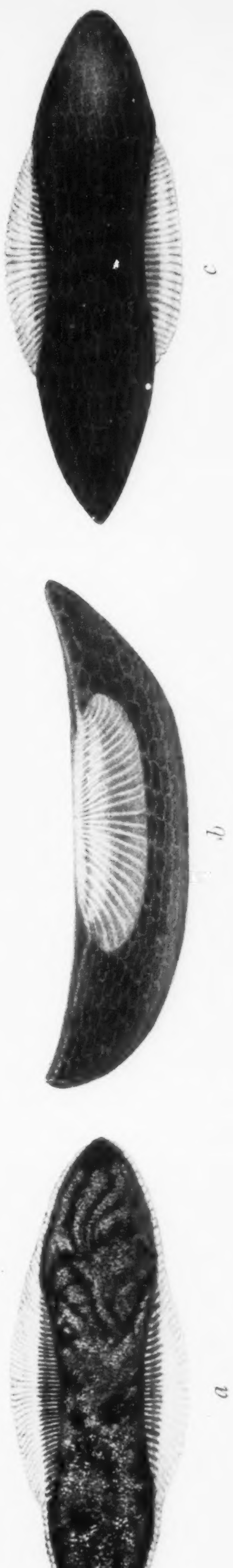

FIG. 1

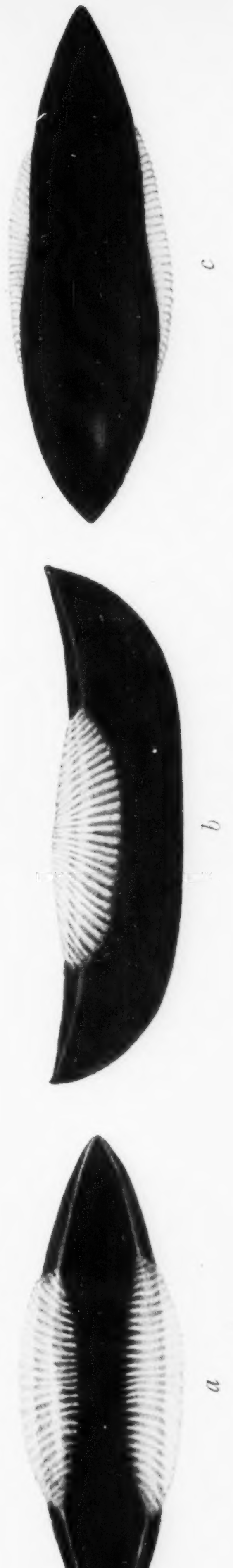

FIG. 2

FIG. 3

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THE TRYPANOCIDAL EFFECT OF PHENYLGLYCINE AMIDO ARSENATE OF SODIUM ON *T. BRUCEI* IN RATS AND *T. RHODESIENSE* IN MICE

BY

S. ADLER, M.B.

(*Received for publication* 23 *November*, 1921)

This drug* is a white amorphous powder readily soluble in distilled water, and yielding in 5 and 10 per cent. concentration a perfectly clear, colourless solution. On standing, however, for some days, a yellow colour develops, whether the solution is kept exposed to light or in the dark. A 5 per cent. solution when exposed to light became yellow in seven days; when kept in the dark, in six days. Daily sterilizing for ten minutes did not prevent the development of the yellow colour, but rather accelerated it.

Rats. Minimum lethal dose. In Table I are set out the experiments performed in order to ascertain the minimum lethal dose for rats; in all cases the drug was used in a freshly prepared solution of 5 or 10 per cent., and was injected intraperitoneally; it produced no irritation. Healthy and infected animals were used in this experiment.

It will be seen from the table that no dose was toxic to the animals injected until the amount of 1·2 gms. per kilo was attained.

Relationship of Toxicity to age and change of colour of solutions.

The number of experiments bearing on this point is rather limited, but serves to show that the toxicity increases on standing, *e.g.*, although the minimum lethal dose of freshly prepared solution for rats proved to be 1·2 gms. per kilo body weight, an animal which was injected with 0·18 gms. per kilo of a twenty-four hour old solution followed on the next day by a dose of 0·36 gm. per kilo of a forty-eight hour old solution, died after severe symptoms of poisoning on the sixth day after the second injection. In the

* Kindly put at our disposal by Messrs. May & Baker, Ltd., Battersea, London.

Table I.

Showing the minimal lethal dose for rats.

No. of Experiment	Dose in gms., per kilo	Infected or healthy	Remarks
1	0·33	Healthy	No toxic effects
2	0·46	Healthy	No toxic effects
3	0·43	Healthy	No toxic effects
4	0·67	Infected	No toxic effects
5	0·68	Infected	No toxic effects
6	0·7	Infected	No toxic effects
7	0·71	Healthy	No toxic effects
8	0·75	Infected	No toxic effects
9	0·82	Infected	No toxic effects
10	0·90	Infected	No toxic effects
11	1·0	Healthy	No toxic effects
12	1·1	Healthy	No toxic effects
13	1·2	Infected	Animal died in 22 hours
14	1·4	Healthy	Died on 4th day

above solution, although highly toxic, no change in colour was evident. Further experiments proved that in still older solutions the toxicity diminished, *e.g.*, on the eleventh day, when the solution was deeply yellow, three animals were each given a dose, approximately equal to the combined doses given above, without producing any symptoms. The first of these three animals was injected with a solution which had been kept in the daylight and boiled each day for ten minutes, the loss from evaporation being made up by addition of distilled water to the original volume before injection. The second was injected with a solution which was unboiled and kept in daylight; the third with solution unboiled and kept in the dark.

The increase in toxicity which was evident in the forty-eight hour old solution, was accompanied by a definite increase in trypanocidal power, for after injection of 0·36 gm. per kilo, trypanosomes disappeared from the peripheral blood within twenty hours, and were absent from the blood until the time of death. Examination for trypanosomes of the organs by smears proved negative, as did also the injection of emulsion of organs and blood into healthy rats. A similar sterilizing effect could only be produced by much larger doses of the freshly prepared drug, *e.g.*, a dose of 0·67 gms. per kilo in freshly prepared solution injected into a rat at approximately the same stage of infection as the previous one, only caused the disappearance of the parasites from the peripheral blood in forty-eight hours, and did not prevent their re-appearance twenty-four hours later.

Toxic effects of freshly prepared solutions.

No toxic effect was observed below the dose of 1·2 gms. per kilo; a heavily infected animal died within twenty-four hours of receiving this dose. The signs of poisoning noted before death were blindness and refusal to take food. No gross haemorrhages were found after death, but the whole intestinal tract showed numerous minute haemorrhages. No trypanosomes were found in the peripheral blood, either immediately before or after death.

Toxic effects of old solutions.

Toxic effects were noted after a dose of 0·36 gm. per kilo, but not until four days had elapsed. On the fifth day the

animal appeared ill, lying curled up, breathing irregularly and spasmodically, it refused food, was blind, and staggered in its gait when moved. Haemorrhages were observed from the conjunctiva, anus and urethra. Post-mortem, the whole intestinal tract was found to be haemorrhagic, the liver was enlarged and soft, and showed yellow mottling; the kidneys were very soft, but not enlarged nor dark in colour; the spleen showed yellowish patches.

Minimum curative dose.

In Table II are set out the experiments performed in order to demonstrate the minimum curative dose in rats.

TABLE II.

Shewing effect on rats infected with *T. brucei*.

Experiment	Trypanosomes per field. Ocular 4, Obj. 1/8	Dose in gms., per kilo	Day of disappearance of trypanosomes from peripheral blood	Day of re-appearance	Remarks
1	40	0·33	1	5	...
2	Swarming	0·67	2	3	...
3	Swarming	0·68	1	2	...
4	Swarming	0·7	1	...	No relapse after 7 months
5	36	0·75	1	...	No relapse after 7 months
6	14	0·82	1	...	No relapse after 7 months
7	25	0·91	1	...	No relapse after 7 months
8	Swarming	1·2	...	...	Died in 22 hours. No. trypanosomes
Control	Swarming	0·17 (atoxyl)	1	17	...

It will be seen from the above table that while the atoxyl control animal was rendered free from trypanosomes in its peripheral blood

TABLE III.

Showing effect on mice infected with *T. rhodesiense.*

Experiment	Trypanosomes per field. Ocular 4, Obj. 1/8	Dose in gms., per kilo	Day of disappearance of trypanosomes from peripheral blood	Day of re-appearance	Remarks
1	Swarming	0·5	2	4	...
2	Swarming	0·6	2	6	...
3	Swarming	0·74	2	5	...
4	Numerous	0·83	1	8	...
5	Numerous	0·9	2	5	...
6	Swarming	0·9	1	4	...
7	Numerous	1·0	2	5	...
8	Swarming	1·1	2	...	Alive and well 5 months later
9	Numerous	1·25	2	4	...
10	Numerous	1·6	1	6	...
11	Numerous	2·0	1	12	...
12	Swarming	2·5	2	7	...
13	Control	3·0	...	...	Died after 3 days

by 0·17 gms. atoxyl per kilo, but relapsed in seventeen days, the experimental animals were rendered free from trypanosomes when a dose of 0·7 gms. per kilo of phenylglycine amido arsenate of sodium was reached, and did not relapse.

Action in Vitro.

No trypanocidal action in vitro was observed, either by the drug itself or by the serum of animals, twenty-four hours after they had been rendered free from trypanosomes by injection of the drug.

Mice. Minimum Lethal Dose.

In Table III are set out the experiments performed in order to demonstrate the minimum lethal dose for mice and the effect on *T. rhodesiense.*

It will be seen from the table that the minimum lethal dose was 3 gms. per kilo; the effect on the trypanosomes was negligible up to a dose of 2·5 gms. per kilo, only one animal failing to relapse.

SUMMARY

Phenylglycine amido arsenate of sodium can be used in freshly prepared solutions in distilled water for intraperitoneal injection into rats and mice; the solutions on standing become toxic, and later become yellow in colour.

For rats, the minimum lethal dose of the freshly prepared drug proved to be 1·2 gm. per kilo of body weight.

For rats infected with *T. brucei*, the minimum curative dose is 0·7 gm. per kilo of body weight.

In vitro the drug has no appreciable action on trypanosomes, nor has the blood of treated animals immediately (twenty-four hours) after becoming trypanosome-free.

The drug has no curative effect on mice infected with *T. rhodesiense.*

A remarkable feature of this drug is its relatively high minimum lethal dose. Although the drug contains 26 per cent. arsenic, the minimum lethal dose was found to be 1·2 gms. per kilo for rats and 3 gms. for mice.

I am indebted to Professor Blacklock for carrying out the necessary inoculations for the experiments.

NOTE ON BISMUTH AS A TRYPANOCIDE

BY

S. ADLER, M.B.

(*Received for publication* 23 *November*, 1921)

The effect of bismuth in the form of soluble bismuth sodium tartrate in solutions of various strengths was tried on animals infected with *T. rhodesiense* and *T. brucei* (*Nagana ferox*) respectively.

Using this drug, the minimum lethal dose for healthy mice was found to be 0·047 grammes of bismuth, and for healthy guinea-pigs 0·062 grammes of bismuth per kilo body weight.

In animals which died after injection of bismuth sodium tartrate deposits of bismuth were found in all cases in the liver, frequently in the spleen, and less frequently in the kidneys.

T. rhodesiense.

The minimal lethal dose cleared the blood of trypanosomes in a mouse within twenty-four hours, but the animal died in two days. Any dose below this failed to clear the blood of trypanosomes.

T. brucei (*Nagana ferox*).

Although the drug cleared the blood of trypanosomes in guinea-pigs, yet relapses occurred in a few days, thus :—

Dose per kilo, body weight	Injected	Trypanosomes re-appeared
0·018	20.4.21	28.4.21
0·022	26.4.21	2.5.21
0·024	9.5.21	18.5.21
0·032	9.5.21	21.5.21

In no case was a cure obtained.

I am indebted to Professor Blacklock for carrying out the necessary inoculations for these experiments.

MALARIA ON A VENEZUELAN OILFIELD

BY

J. W. W. STEPHENS, M.D., F.R.S.

(*Received for publication* 5 *December*, 1921)

PLATES XXIII AND XXIV

The oilfield is situated on the eastern side of Lake Maracaibo, Venezuela, about 80 miles from the head of the lake, and 10 miles inland from its shores. The following observations were made in the month of August, 1921.

MALARIA IN THE NATIVE POPULATION

The extent to which malaria prevailed in the native population of various villages in the district is shown in the following table:—

Age Period	0—10		11—20		21—	
	No. exam.	Percentage infected	No. exam.	Percentage infected	No. exam.	Percentage infected
Old Village	10	10	8	12·5	0	—
New Village	32	46·8	39	23·0	49	8·1
San Pedro	9	66·6	6	0·0	1	0·0
Los Barrosos	9	0·0	9	0·0	0	—
San Timoteo	27	3·7	4	0·0	0	—

The relationship of malaria in the Old Village and New Village respectively to malaria among the white employees on the oilfield we shall discuss later. The other three villages were not in the immediate neighbourhood of the oilfield, but it may be pointed out here that the absence of infection in Los Barrosos was probably due to the fact that anophelines were only found at a distance of half a mile, and then only in one small clay-pit about

12 feet square. San Timoteo is a village built on piles over Lake Maracaibo. Its low endemic index, 3·7 in children under ten, is thus probably due to its position over the lake and to the fact that only one small anopheline larva was found after prolonged search on the mainland. San Pedro is four or five miles from the oilfield, and its high rate is probably due to its being situated close to extensive anopheline swamps.

SPECIES OF PARASITES FOUND

In over two hundred blood specimens examined, malignant tertian malaria (crescents) was only found twice, simple tertian and quartan parasites were about equally common, a peculiarity of infection which I had not previously seen in Africa or India. The frequency with which pigmented leucocytes were observed in the 'positive' films was a noteworthy feature.

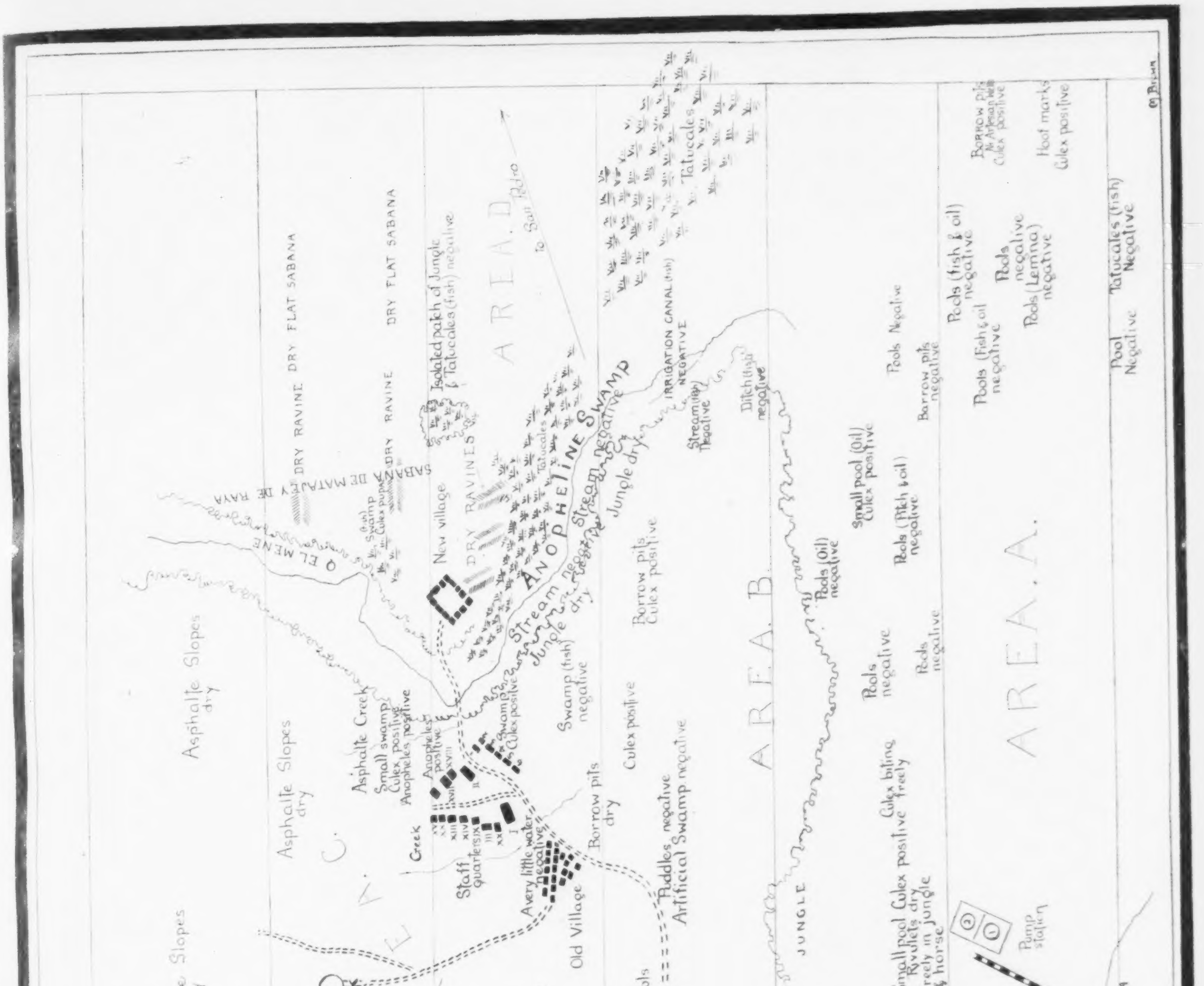
MALARIA AMONG THE WHITE STAFF

No precise information was forthcoming as to the nature of the sickness among the white employees (about thirty in number). An examination of the blood of sixteen employees in apparent good health revealed nothing. In the case of one employee suffering from fever, simple tertian parasites were found. In the absence of definite records, one had therefore to assume that the sickness prevalent among the staff was due to malaria.

POSITION OF THE STAFF HOUSES

They are situated (*vide* Map), (1) on two ridges a few hundred yards from the first source of *Anopheles*, viz., the small anopheles swamp in the Asphalte creek, the houses on the easterly ridge actually overlooking the swamp. (2) From the second source of *Anopheles* the 'Anopheles Swamp' which begins due west and even north-west of the New Village, they are situated less than half a mile. (3) They are situated less than a quarter of a mile from a source of malaria infection, the Old Village, and (4) since the year 1920 half a mile from a second source of infection, the New Village.

We have here then an example of the conditions so frequently



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founds in the tropics, namely, native villages and a source of *Anopheles* in close proximity to a white population, and here, as elsewhere, the conditions would completely explain the existence of malaria among the white employees.

THE ANOPHELINES

The district under investigation can be divided into four areas:—

A. The Jungle.
B. The cleared area.
C. The residential and Old Village area.
D. The New Village area.

The relative positions of these will be seen on the map.

AREA A. THE JUNGLE.

Numerous examinations were made of all discoverable water in the jungle so far as it was penetrable. In many cases, pools and streams and 'tatucales,'* apparently favourable breeding-places, were examined with negative result, often, no doubt, due to the presence of abundance of small fish (in some cases due to a covering of *Lemma* (duckweed). In other cases, however, jungle pools were '*Culex*' positive.

One interesting example was encountered, viz., that of a borrow-pit, where the snouts of dozens of small fish could be seen voraciously hunting the surface for food, and yet '*Culex*' larvae in abundance were found in the protecting weed and rubbish at the sides, but none away from there.

Again where the jungle was apparently dry over large areas, yet '*Culex*' was present and bit freely in the daytime when one stood still.

Anopheles (mosquitoes or larva) was, then, absent from the jungle at least in August, and mosquitoes caught in the jungle at long distances from the oilfield were invariably '*Culex*.'

AREA B. THE CLEARED AREA.

Here and there a few '*Culex*' breeding-grounds were found, generally in small numbers. A swamp a hundred yards or so long,

* Tatucales: Diminutive islands or mounds intersected by water, and in which progress could only be made by a series of jumps.

passing in front of the native mechanics' quarters 1 to 6 and close to the next area, is of interest in that repeated search showed it to be *Anopheles* negative, but it contained a small '*Culex*' area near its origin. It had been already partly, but incompletely drained, and fish abounded.

AREA C. STAFF HOUSES AREA.

The Staff Houses are situated for the most part on two ridges themselves separated by a dry ravine. These ridges are bounded on the N.W. and N.E. by the Mene Grande and Asphalte creeks respectively. These creeks merge at their origin northwards, and are bounded by the slopes of the ridge on which the Star Water tank is situated. Again further north to the west and the east this ridge descends in sloping ground, dry for the most part and covered with asphalte until in a N.W. direction the creek 'Piedritas blancas' is reached.

The whole of this large area is for the most part dry. What little water there is, is found in the slopes draining to the road from the Old Village to Zo, but frequent examinations of all collections of water in this area were negative. As regards the Asphalte creek itself, this was also negative except for a small swamp some fifty yards long in its upper portion. Here *Anopheles* larvae in scanty numbers were found. The rest of the creek had already been drained; the ditches contained numerous fish and considerable quantities of oil. The swamp above referred to was caused by a small depression in the surface, and was easily abolished by cutting the long grass and filling with earth from the adjacent higher ground.

AREA D.—OR NEW VILLAGE AREA.

The New Village is situated on the Sabana de Matajey de Raya on elevated ground (thirty metres) a hundred yards or more from the creek El Mene or water creek. From the elevated flat ground on which the village lies a number of dry ravines lead down to a swamp some fifty yards or so in width, bordering the stream formed by the junction of the streams from the Asphalte and El Mene creeks. This swamp extends along the edge of the Sabana in a curved course (probably as far as San Pedro), and was found to contain Anopheline larvae—always, it is true, scanty in number—for a distance of,

roughly, about three-quarters of a mile. Although fish were plentiful in the two drains that had already been cut in part of it, but which were blocked when examined by me, yet *Anopheles* were present always in small numbers, but from its extent this swamp and its tributary swamps (*vide* infra) formed the *main source of Anophelines*. The Tatucales, out in the Sabana, contained fish, and was negative.

The ravines below the village to which reference has been made, extend in a south-easterly direction, becoming less steep and with flatter bottoms so that they are no longer dry but are occupied by swamps; it is these secondary tributary swamps and the main swamp which they eventually join, which formed the great Anopheline breeding-ground.

In the four areas examined, *Anopheles* were found breeding in two only, and in one of these only in a swamp of small dimensions. The breeding-grounds were thus in August definitely restricted; *Anopheles* were not breeding in the jungle nor in the open cleared area, nor in the waters that existed on the asphalte slopes of Area C.

The swamp in which *Anopheles* were found breeding was overgrown with a variety of grasses, some up to 6 ft. high; in other parts it more resembled marshy ground with short rushes in part trodden by cattle; in other parts again 'tatucales' formation. In no case were *Anopheles* found amidst overhanging trees.

Anopheles (*C. argyrotarsis*) were also found breeding in one of half a dozen clay borrow-pits some three miles away from the camp.

Adult Anophelines.

The search for anophelines in the native huts in the daytime was completely fruitless, and culicines also were very scanty. This condition was in marked contrast to those observed by me in the neighbourhood of Lake Valencia, which I visited on my way home, where in the daytime, in the verandah of a hut, it was easy to collect numerous anophelines, embracing three different species. On the oilfield itself I was only able to secure by capture at night in the native village sixteen specimens of *C. argyrotarsis*, and during my stay in the camp no anophelines and very few culicines were seen by

me in the house I occupied. It should be stated that the windows of all the houses in the camp were wire-screened, and mosquito-nets were in general use.

PROPHYLAXIS

The existence of infection in the Old Village and the absence of *Anopheles* from any area nearer than an isolated small, grass-grown swamp in the Asphalte creek and the great Anopheline Swamp adjacent to the New Village proves, I think, that we have a normal flight range of about half a mile.

We may consider prophylactic measures under the following headings:—

(*a*) DRAINAGE OF ANOPHELINE SWAMP.

Towards the end of my visit, 100 yards or so had been cleared of grass and existing choked drains cleared and additional ones constructed, with the result that the swamp rapidly became dry and free from larvae in this section. I suggested that the swamp should be drained for about a mile. The efficacy of this measure can be estimated by observing the effect (1) on the number of anophelines caught in the New Village month by month; (2) on the endemic index of the New Village; (3) on the sickness rate of the white staff. If the drainage results in a complete or almost complete suppression of anophelines, further measures would hardly be necessary, but in the event of this not being so, other measures would have to be adopted.

(*b*) REMOVAL OF THE OLD VILLAGE.

This source of infection in close proximity to the white staff quarters should be abolished, and if further protection is sought various stray native huts which exist here and there should also be removed.

(*c*) THE NEW VILLAGE.

If drainage of the anopheline swamp is unsuccessful, it would be necessary to consider the question of removal of the New Village to an area free from anopheline breeding-places; such a one existing

a mile or so from its present position. For elimination of malaria from the village itself, quinine administration is advisable; and further, if it remains in its present position wire screening of the huts could be advantageously employed, without prohibitive cost.

(*d*) A more fundamental and expensive procedure would be the removal of the white staff houses. An ideal site for these exists on the Star Tank ridge, at an elevation of about 300 ft. and at a distance of about a mile from the New Village and Anopheline Swamp.

One sees, accordingly, that the existing conditions have arisen from a lack of appreciation of the fundamental principles responsible for the infection of the white man amidst a native population, namely, close propinquity to that population, with a supply of anophelines also adjacent. Had one been laying out the camp de novo, the following arrangement would, I believe, have led to the protection not only of the white but also of the native population:—(1) The white staff houses should have been placed on the Star Tank ridge; (2) the native village should have been placed a mile from this site and also a mile from the source of anophelines.

The conditions prevailing were particularly favourable for such an arrangement, namely, (1) the complete absence of anopheline breeding-grounds over a large part of the area considered, and (2) the large tract of ground in which collections of surface water of any sort were absent (in August).

NOTES

The oilfield was situated in Lat. 9°.75′ N. and Long. 71°.15′ W. The indoor temperatures in August ranged from 85°-89·5° F. maxima to 75°-81·5° F. minima. Heavy rain lasting about half an hour fell towards evening on five out of twenty days.

The only species of Anopheline found in the area was *Cellia argyrotarsis*, distinguished by having three and three-quarters hind tarsi almost completely white. The palmate hairs of the larva of this species are variable. Usually there are palmate hairs on segments two to seven, that on segment two being small and hard

to see. Examples were also found with well developed palmate hairs on segments one to seven, together with a well developed thoracic palmate hair.

Examinations of sixteen specimens of *C. argyrotarsis* for sporozoites proved negative, but Tovar states that this species transmits in Venezuela.

The small fish which abounded in the small streams and in the swamps of the district belonged to the following species:—

Gambusia (*Poecilia*) *tridentigera*,
Haplochilus sp., and
Chromides (*Acara*) *dorsigera*.

EXPLANATION OF PLATE XXIV

FIG. 1. Old type of Bungalow.

FIG. 2. Modern type of Bungalow.

FIG. 3. [illegible]

FIG. 4. [illegible] The ridge with [illegible] Water Tank in the distance.

FIG. 5. [illegible] point to two [illegible]

EXPLANATION OF PLATE XXIV

Fig. 1. Old type of Bungalow.

Fig. 2. Modern type of Bungalow.

Fig. 3. The Peons' Cock-pit.

Fig. 4. Bird's-eye view of Staff houses. The ridge with Star Water Tank in the distance.

Fig. 5. The Asphalte slopes. The arrows point to two asphalte mounds.

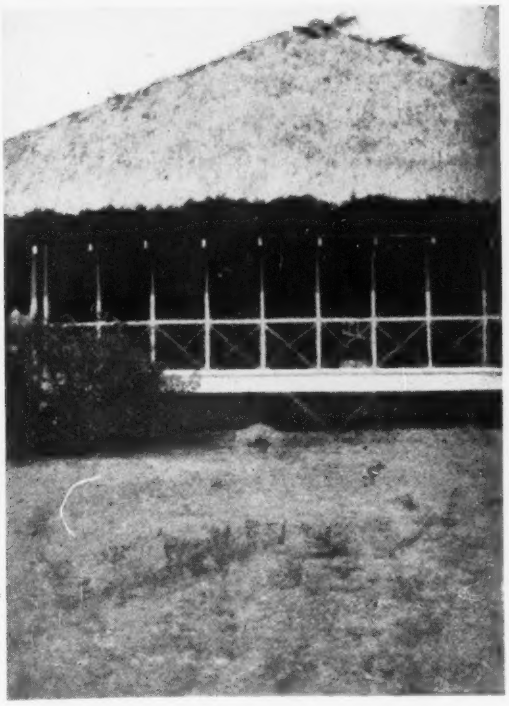

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5

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NOTES ON CULICIDAE COLLECTED IN VENEZUELA

BY

A. M. EVANS, M.Sc.

(*Received for publication* 25 *November*, 1921)

PLATES XXV AND XXVI

During the course of the investigations in Venezuela, recorded in the foregoing paper, a number of mosquitoes were collected by Professor Stephens at Mene Grande, which is situated about ten miles inland from Lake Maracaibo. Specimens were also caught at Maracay near Lake Valencia, which is separated from Lake Maracaibo by a range of mountains, and on the Island of Curaçao. The following is a list of the species collected at each of the three places:—

LAKE MARACAIBO

Anopheles argyrotarsis, R.D.

Hatched from larvae taken in swamp ♂♂ 3, ♀♀ 6. Mene Grande, 22.8.21, ♀♀ 5.

Aedes serratus, Theo.

Mene Grande, 3.8.21, ♀♀ 6. Biting in jungle, Mene Grande, 5.8.21, ♀♀ 6. Caught in jungle, biting horse and man, 5.8.21, ♀ 1; 11.8.21, ♀♀ 11.

Aedes scapularis, Rond.

Mene Grande, jungle, 11.8.21, ♀♀ 3.

Taeniorhynchus titillans, Walk.

Mene Grande, biting in jungle, ♀♀ 3.

Culex (*Neomelanoconion*) *chrysothorax*, Newstead and Thomas.

Reared from pupa taken in swamp, Mene Grande, 7.8.21, ♀ 1.

**Culex* (*Culex*) *coronator*, D. and K.

Mene Grande, 6.8.21, ♂♂ 4, ♀♀ 6. Hatched from larvae, Mene Grande, 1.8.21, ♂♂ 2; 11.8.21, ♀♀ 2; ♂♂ 3, ♀ 1.

**Culex* (*Culex*) *nigripalpus*, Theo.

Mene Grande, ♂ 1.

Psorophora posticata, Wied.

Mene Grande, 11.8.21, ♀♀ 2.

Joblotia digitatus, Rond.

Jungle, Mene Grande (about 20 miles inland from Lake Maracaibo), 20.8.21, ♀♀ 2.

MARACAY
(about 10 miles from Lake Valencia)

Anopheles argyrotarsis, R.D.

Maracay outskirts, 8.9.21, ♀ 1.

Anopheles albimanus, Wied.

Maracay outskirts, 8.9.21, ♂ 1, ♀ 1.

Anopheles albimanus var. tarsimaculatus, Goeldi.

Maracay outskirts, 8.9.21, ♂ 1, ♀ 1. Maracay outskirts, 5 specimens.

Anopheles pseudopunctipennis, Theo.

Maracay outskirts, 7 specimens.

Aedes scapularis, Rond.

Maracay outskirts, 8.9.21, ♀ 1.

Aedes trivittatus, Coq.

8.9.21, ♀♀ 2.

**Culex* (*Culex*) *quinquefasciatus*, Say.

Maracay outskirts, 8.9.21, ♂♂ 3.

**Culex* (*Culex*) *virgultus*, Theo.

Maracay outskirts, 8.9.21, ♂ 1.

Psorophora posticata, Wied.

Maracay outskirts, 8.9.21, ♀ 1.

* Determined by the male genitalia (*See* Dyar, 1918).

CURAÇAO

Aedes (Stegomyia) fasciata, Fabr.
Breeding in tub, Ice Factory, Curaçao, 1.9.21, ♀ 1.

**Culex (Culex) quinquefasciatus*, Say.
From larvae breeding in tub of ice manufacturer, 30.8.21.
♂♂ 9, ♀♀ 11; 1-2.9.21, ♂♂ 14, ♀♀ 31.

THE MORPHOLOGICAL CHARACTERS OF *ANOPHELES ARGYROTARSIS*, R.D., AND *A. ALBIMANUS*, WEID.

Larvae. In their Monograph, Howard, Dyar and Knab (1917), state that palmate hairs occur only on abdominal segments two to seven in *A. argyrotarsis*, but that in *A. albimanus* there is an additional small pair on the first abdominal segment. The larvae of *A. argyrotarsis*, which Professor Stephens collected from the swamps around Mene Grande, however, all possessed these structures on the first segment of the abdomen. In some specimens these were in a reduced and incomplete condition, but in a certain number they were well developed, and in these latter specimens a pair of palmate hairs was also present on the thorax, a position in which they do not appear to have been recorded hitherto in either of these species. The distribution of these structures is thus shewn to be variable in the two species, and cannot be used as a specific character for determination of the larvae.

Male hypopygium. In view of the close resemblance between the adults of these species, it appeared desirable to compare the detailed structure of the male hypopygium. The figures in the Monograph of Howard, Dyar and Knab (1912) tend to exaggerate the differences present, and it is obvious that the morphology was not clearly understood. Christophers (1915) described the hypopygium of *A. albimanus*, and placed in one group with this species *A. argyrotarsis*, *A. tarsimaculata*, and *A. bellator*. This group was based on the number and arrangement of the large spines arising from the side-piece, but Christophers stated that it was imperfectly studied. Edwards (1920) referred to the structure of the *mesosome* (theca) of *A. argyrotarsis*, saying that it approached nearest to the simple form seen in *Ochlerotatus*.

*Determined by the male genitalia (see Dyar, 1918).

Before comparing the hypopygium of the two species, it is necessary briefly to discuss the structure of certain of the constituent parts. The nomenclature employed is that proposed by Edwards (1920). The *mesosome* (theca) of *A. albimanus* has been described and figured as 'massive and clubbed.' This appears to have been due to confusion of the mesosome with a wide median membraneous lobe (fig. 2 A and B, *m.l.*) which arises from the membrane at the base of the side-pieces on their upper (by rotation) sides. The position of

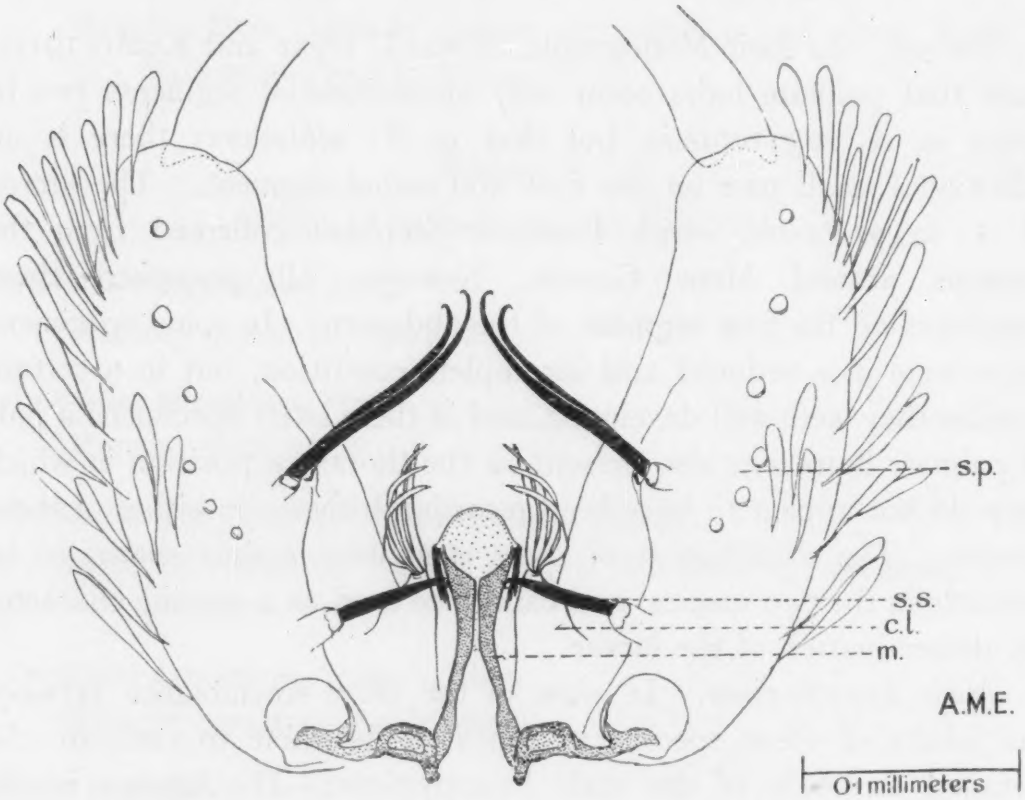

FIG. 1. ♂ Hypopygium of *A. argyrotarsis* from below; tenth sternite not shown. *cl.*, claspette; *m.*, mesosome; *s.p.*, side-piece; *s.s.*, stalked spine.

this lobe in relation to the side-pieces is shewn in the drawings (fig. 2 A and B). Distally it becomes bilobed, and the two halves are produced downwards (towards the tenth sternites) so as to embrace the distal half of the mesosome. So intimately are the distal portions of the lobe associated with the mesosome, that in mounted preparations it is often impossible to distinguish the separate structures. When examined floating in oil under a binocular microscope, however, and arranged so that a terminal view

is obtained the mesosome can be seen lying ensheathed on three sides by the median lobe, and its downward processes. The separate parts can then be dissected away and isolated. The form of the mesosome and median lobe afford what appear to be reliable

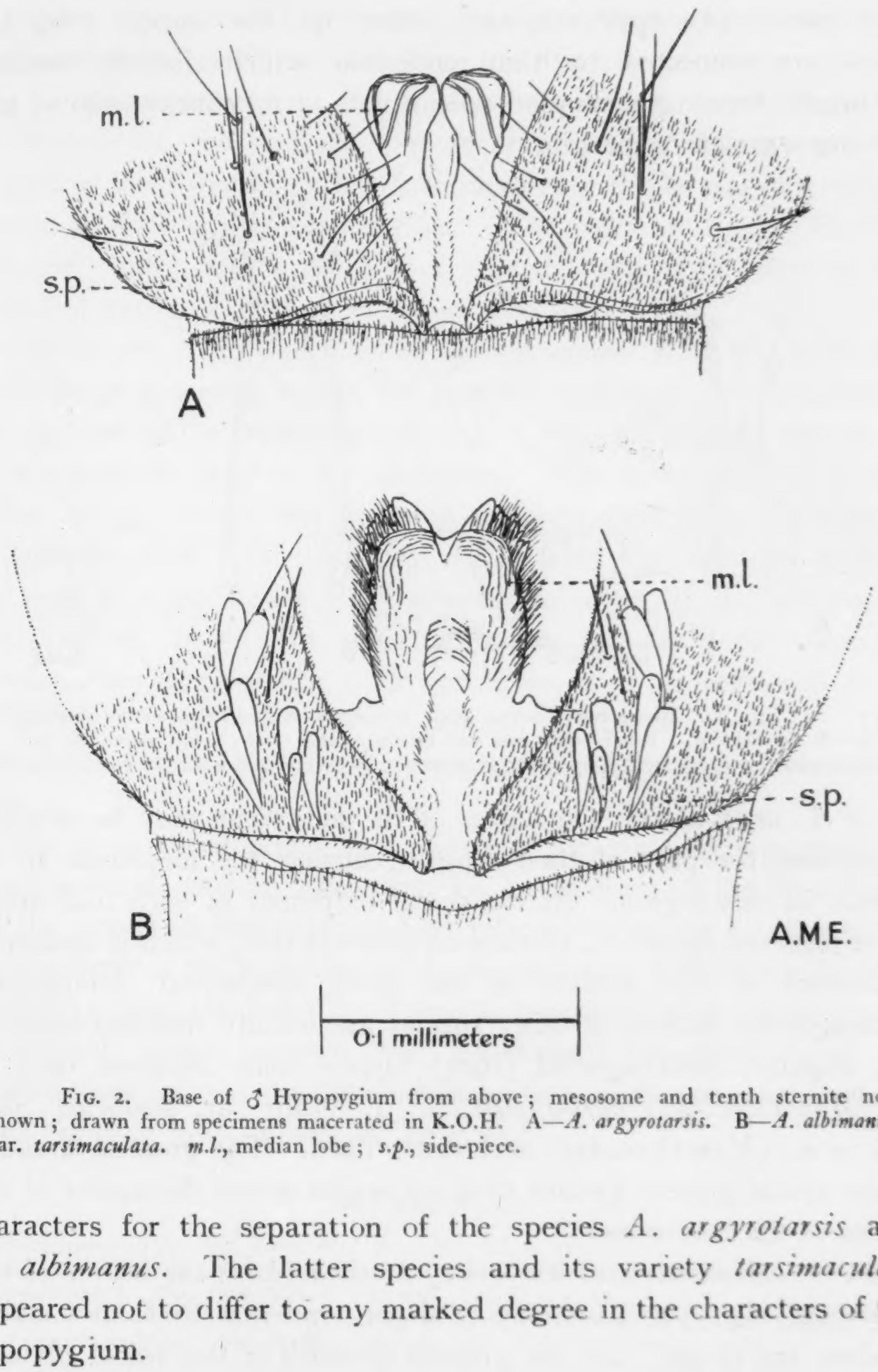

FIG. 2. Base of ♂ Hypopygium from above; mesosome and tenth sternite not shown; drawn from specimens macerated in K.O.H. A—*A. argyrotarsis*. B—*A. albimanus* var. *tarsimaculata*. *m.l.*, median lobe; *s.p.*, side-piece.

characters for the separation of the species *A. argyrotarsis* and *A. albimanus*. The latter species and its variety *tarsimaculata* appeared not to differ to any marked degree in the characters of the hypopygium.

The Mesosome (fig. 3 A and B). It was found that the mesosome can be best studied in specimens stained with carbol fuchsin. In both species the halves of the mesosome are elongate plates, each articulating basally with the chitinous pieces (*p.b.p.*), which represent the parameres and basal plates of other Culicidae. The halves (*h*) approach each other on the upper side, but below are connected by thin membrane which distally becomes chitinised, forming a rounded apical plate (*a.p.*) concave above, and membraneous at its margin.

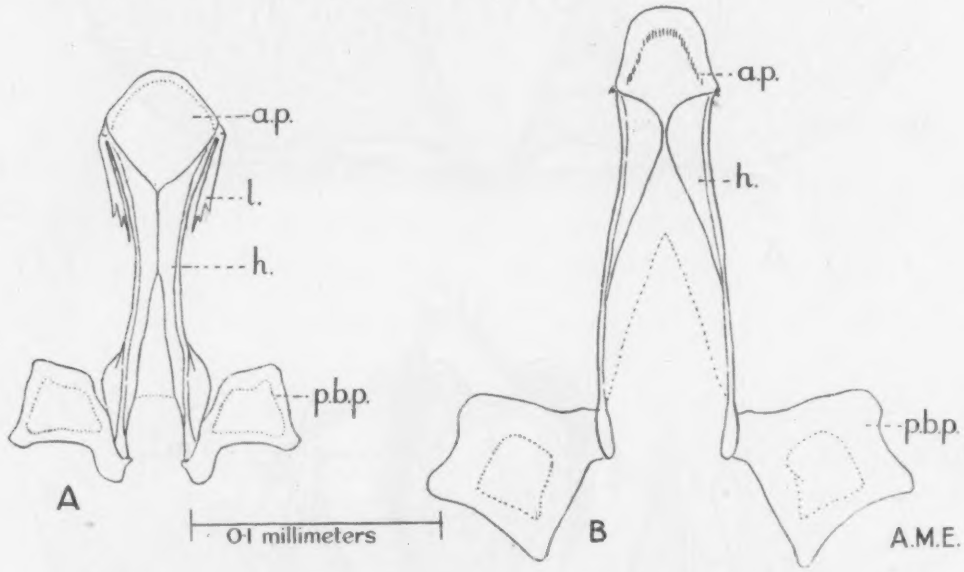

FIG. 3. Mesosome; drawn from specimens stained with carbol fuchsin. A—*A. argyrotarsis*. B—*A. albimanus* var. *tarsimaculata*. *a.p.*, apical plate; *h.*, half of mesosome; *l.*, leaflet; *p.b.p.*, plate representing parameres and basal plates.

In *A. argyrotarsis* the halves of the mesosome may be actually contiguous for part of their length, causing the mesosome to be tubular in this region. At the distal extremity of each half arises a flat recurved spine (*l.*), toothed on its outer side, which is obviously equivalent to the *leaflets* of the more specialised Anophelini. Although the leaflets of other species are usually directed more or less distally, Swellengrebel (1921) figures some recurved ones in *A.* (*Myzorhynchus*) *barbirostris*, v. d. Wulp var. *pallidus*, Sw., and in *A.* (*Myzorhynchus*) *umbrosus*, Theo. The greatest breadth of the apical plate is greater than its height above the apices of the halves of the mesosome.

In *A. albimanus* and its variety *tarsimaculata*, the halves of the mesosome (fig. 3 B) have only a slight tendency to form a tube. Leaflets are absent, and the greatest breadth of the apical plate is

equal to or less than its height above the apices of the halves of the mesosome.

The Median lobe. In *A. argyrotarsis* (fig. 2 A), the distal portions of this structure are composed of a number of parallel divisions, the exact form of which is exceedingly difficult to determine in macerated specimens, owing to the extreme thinness of the membrane, and its liability to distortion. There are no long hairs or setae present. In *A. albimanus* and its variety (fig. 2 B), the surface of the median lobe is thrown into a large number of shallow folds distally, these folds involving the lateral descending portion as well as the upper surface. The sides are thickly clothed with long hairs, and a number of very delicate hairs occur on the surface of the basal portion of the median lobe.

Side-pieces. No well marked specific characters could be found in the large spines borne on the internal surface of the side-pieces. The pedicels of the stalked spines (fig. 1, *s.s.*) are slightly shorter in *A. argyrotarsis* than in *A. albimanus.* The *claspettes* are in the former species broad and not well differentiated from the surface of the side-piece. In this they differ from the separate finger-like condition in which they sometimes occur in *A. albimanus* (Christophers, 1915). In some specimens of the latter species, however, they occur in the same condition as in *A. argyrotarsis.*

The *tenth sternite* is almost identical in the two species. The appearance varies according to the position of the paired chitinous arms.

The main differences, then, between the male hypopygium of *A. argyrotarsis* and *A. albimanus* lie in the form of the mesosome and the membraneous structure here referred to as the median lobe. The character of the mesosome of *A. argyrotarsis,* with its single pair of leaflets and tendency to form a complete tube, suggests a transitional stage between the generalised condition seen in *A. albimanus* and the completely tubular form with numerous leaflets which occur in most species of the genus.

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SWELLENGREBEL (1921). *Overged. u.b. Tijds. v. Ent.,* Deel LXIV, 1921, pp. 39, 40.

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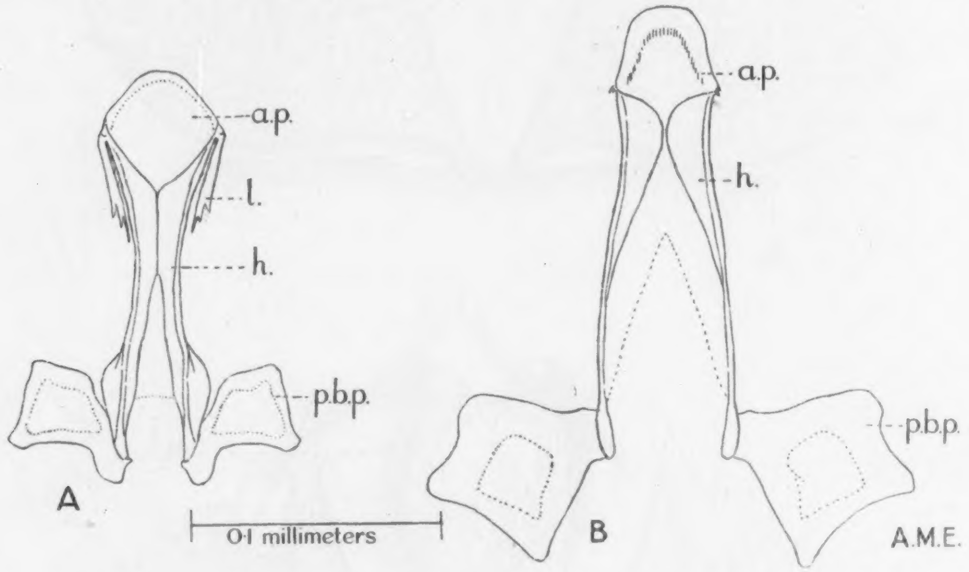

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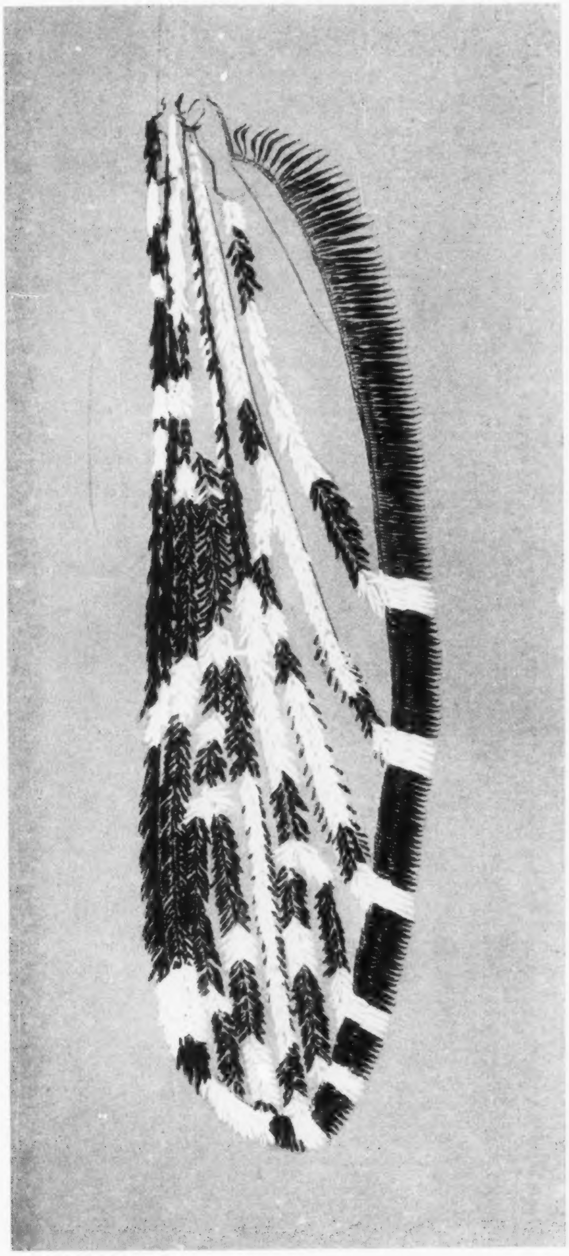
EXPLANATION OF PLATE XXV

Fig. 1. Wing of *Anopheles albimanus* var. *tarsimaculata*.

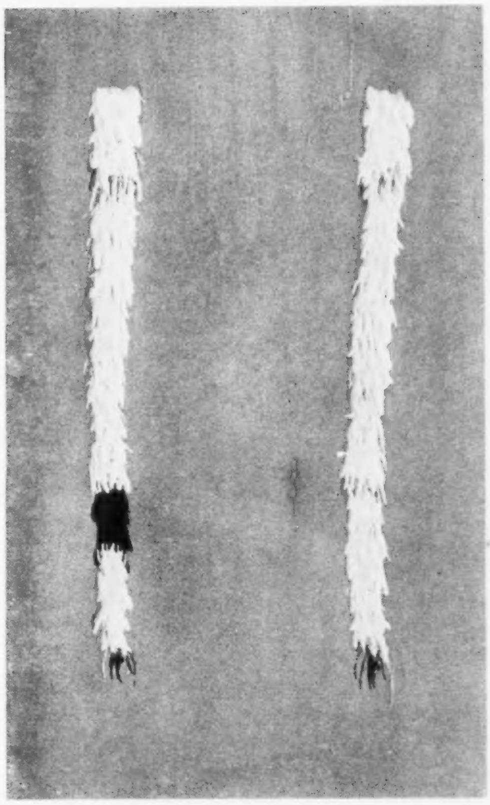
Fig. 2. End of hind tarsus of *A. albimanus* var. *tarsimaculata*.

Fig. 3. End of hind tarsus of *A. argyrotarsis*.



1 millimeter

FIG. 1



0·5 millimeter

FIG. 2 FIG. 3

A. M. Evans, ad. nat. del. *C. Tinling & Co., Ltd., Imp.*

EXPLANATION OF PLATE XXVI

Fig. 1. Wing of *Anopheles punctipennis.*

Fig. 2. Wing of *A. pseudopunctipennis.*

PLATE XXVI

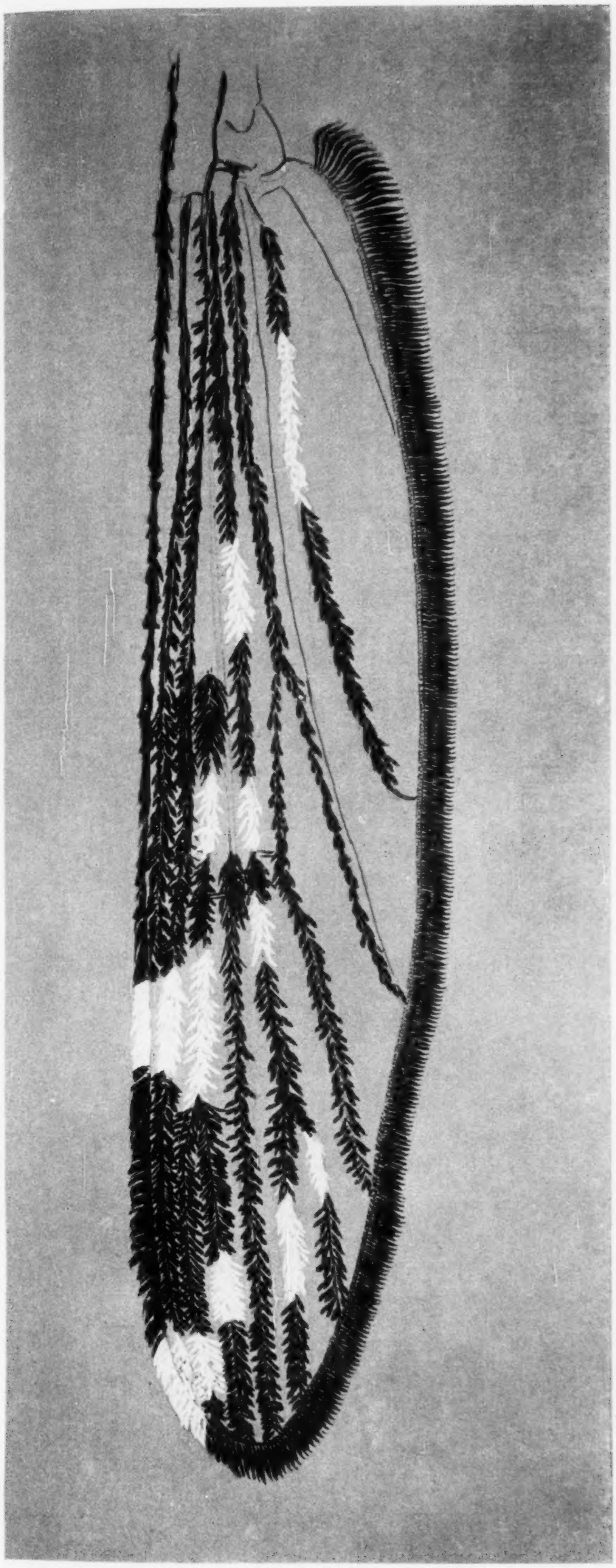


FIG. 1

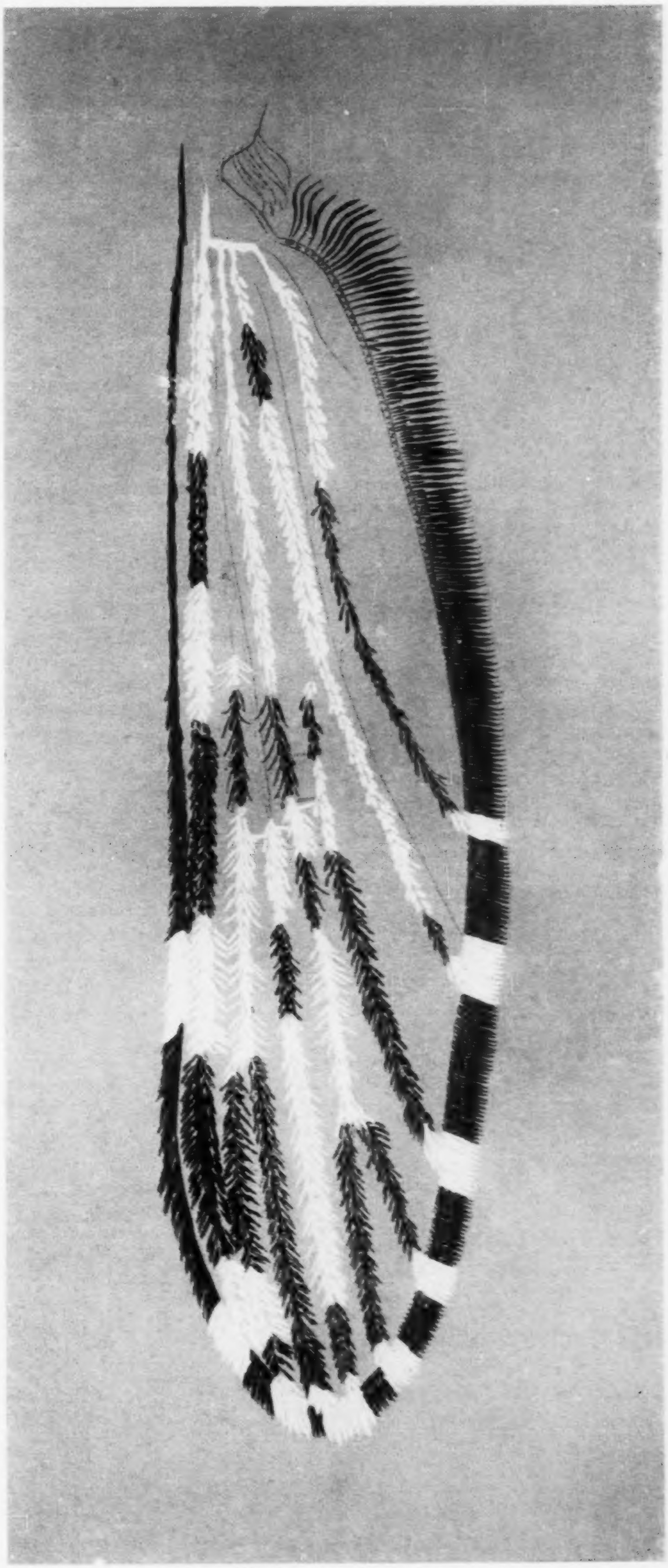
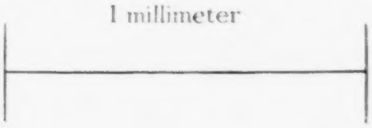


FIG. 2



A. M. Evans, ad. nat. del.

C. Tinling & Co., Ltd., Imp.

A NOTE ON THE SYNONYMY OF THE GENUS *ZSCHOKKEELLA*, RANSOM, 1909, AND OF THE SPECIES *Z. GUINEENSIS*, (GRAHAM, 1908)

BY
T. SOUTHWELL
AND
P. A. MAPLESTONE

(*Received for publication* 29 *November*, 1921)

In Simpson's *Report on Plague in the Gold Coast in* 1908, Graham briefly described a parasite from *Cricetomys gambianum*, to which he gave the name *Davainea* (*guineensis*, n.sp. ?).

We have obtained from the Gold Coast on several occasions, through the kindness of Dr. J. W. S. Macfie, large collections of worms, both from *C. gambianum* and *Epimys* (*Mus*) *rattus*. The examination of this material has led us to make the following observations :—

Beddard (1911, *a*), apparently unaware of Graham's paper, redescribed the same worm under the name *Thysanosoma gambianum*. Beddard (1911, *b*) changed this name to *Thysanotaenia gambiana*, and again (1912) to *Zschokkeella gambianum*. Baylis (1915) described *Z. muricola*, n.sp., from *Epimys* (*Mus*) *rattus*, and Meggitt (1921) described a new species of *Inermicapsifer* (*I. zanzibarensis*), from *C. gambianum*.

We have been unable to find any constant or adequate points of difference between our material and the above three species ; this is clearly indicated in the table below.

For these reasons we have come to the conclusion that the worm *Z. guineensis* has the following synonymy, viz. : *Davainea* (*guineensis*, n. sp. ?) Graham, 1908 ; *Thysanosoma gambianum*, Beddard, 1911 ; *Thysanotaenia gambiana*, Beddard, 1911 ; *Zschokkeella gambianum*, Beddard, 1912 ; *Zschokkeella muricola*, Baylis, 1915 ; and *Inermicapsifer zanzibarensis*, Meggitt, 1921.

We agree with Meggitt (1921) that the genus *Thysanotaenia* should lapse, and that no valid distinction has yet been made between the genera *Zschokkeella* and *Inermicapsifer*. We therefore suggest that the genus *Inermicapsifer*, Janicki, 1910, be likewise suppressed, and all the species in it included in the genus *Zschokkeella*, Ransom, 1909, on account of its priority.

	Z. gambianum, Beddard	Z. muricola, Baylis	I. zanzibarensis, Meggitt	Z. guineensis*
Genital Pore	About the middle. *Note*—Shown anterior in figure.	Anterior.	In anterior quarter.	Varies from the ant to about the midd the same strobila.
Testes	In two separate groups. (This is only implied in the description and is not definitely stated).	In two groups, but almost continuous.	Continuous; but fewer in centre of segments.	May be in two sep groups or these m united by a brid varying numbers testes, in the strobila.
Vesicula seminalis ...	? Present. If so, represented by a pouch near the ovary.	Not seen.	Small and inside cirrus pouch.	Small and inside c pouch. No ext vesicula seminalis
Ovary	May be regarded as paired; partly separated by yolk gland.	Single, fairly compact, lobulated, crescentic.	Single, made up of straggling lobes, long, slender and only slightly connected.	A pear-shaped organ sisting of club-sh acini, with vite glands lying cl posterior.
Receptaculum seminis	Long and not much swollen.	Small rounded organ near ovary.	Large and thin walled. *Note*—This structure appears to be what is usually considered as the vagina.	As in *Z. muricola*
No. of eggs in capsules	A few.	About 20.	One, but 9 to 10 eggs in clusters.	From 3 to about 20. *Note*—Apparently egg capsules first tain about 20 and in later deve ment these divide into cap containing f eggs.

* Diagnosis compiled from observations on our material and from specimens which Dr. Meggitt was kind enough to send us.

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MOSQUITOES AND OTHER BLOOD-SUCKING ARTHROPODS OF THE UPPER SHIRI RIVER, NYASALAND

BY

DR. J. B. DAVEY

AND

PROFESSOR R. NEWSTEAD

(*Received for publication* 23 *November*, 1921)

This paper deals with the mosquitoes and other sanguivorous Arthropods observed in a relatively small area on the banks of the Shiri River, a little south of Lake Malombe, in the Nyasaland Protectorate, British Central Africa. Our captures were made during the dry season, from July to the beginning of November, in the year 1911. No special effort was made by us to collect such material, and no search for the breeding-places of mosquitoes was undertaken.

Our camp occupied a position about 200 yards from the river, the intervening space being comparatively free from 'bush' or other forms of vegetation. Hereabouts the river banks were low, and partly or wholly submerged during the rains. Nearby the banks were elevated and clothed with tall forest trees, and beneath them there was a dense and almost impenetrable undergrowth. Two-thirds of the river was rendered impassable by the 'sudd,' which was composed of a dense floating platform of aquatic plants, serving as a retreat for many species of birds, the crocodile and the hippopotamus. The sudd consisted largely of grasses, and in places extensive colonies of papyrus; the fringe being composed chiefly of the beautiful 'water caltrops' (*Trapa bispinosa*) and the equally troublesome 'cabbage' or 'duckweed' (*Pistia stratiotes*).

MOSQUITOES (CULICIDAE).

Anopheles (*Myzorhynchus*) *mauritianus*, Grandpré. This fine Anopheline was by no means common in our camp, as in all only ten examples were captured; nearly all of these came into our dining-hut

	Z. gambianum, Beddard	*Z. muricola*, Baylis	*I. zanzibarensis*, Meggitt	*Z. guineensis**
Genital Pore	About the middle. *Note*—Shown anterior in figure.	Anterior.	In anterior quarter.	Varies from the anterior to about the middle, in the same strobila.
Testes	In two separate groups. (This is only implied in the description and is not definitely stated).	In two groups, but almost continuous.	Continuous; but fewer in centre of segments.	May be in two separate groups or these may be united by a bridge of varying numbers of testes, in the same strobila.
Vesicula seminalis ...	? Present. If so, represented by a pouch near the ovary.	Not seen.	Small and inside cirrus pouch.	Small and inside cirrus pouch. No external vesicula seminalis seen.
Ovary	May be regarded as paired; partly separated by yolk gland.	Single, fairly compact, lobulated, crescentic.	Single, made up of straggling lobes, long, slender and only slightly connected.	A pear-shaped organ consisting of club-shaped acini, with vitelline glands lying closely posterior.
Receptaculum seminis	Long and not much swollen.	Small rounded organ near ovary.	Large and thin walled. *Note*—This structure appears to be what is usually considered as the vagina.	As in *Z. muricola*
No. of eggs in capsules	A few.	About 20.	One, but 9 to 10 eggs in clusters.	From 3 to about 20. *Note*—Apparently the egg capsules first contain about 20 eggs, and in later development these subdivide into capsules containing fewer eggs.

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Anopheles (*Myzorhynchus*) *mauritianus*, Grandpré. This fine Anopheline was by no means common in our camp, as in all only ten examples were captured; nearly all of these came into our dining-hut

while we were sitting at the table after dark. It is just possible that they may have been attracted by the artificial light; but of this we could not be certain. It did not seek shelter in the tents, as in the case of *Anopheles funestus*, and, therefore, does not appear to be a strictly 'domestic' species. With one exception, the specimens were of the dark form such as has been recorded from south of the Zambesi, and were characterized by the absence of spots either upon the costa or the fringe; the palpi presented three very narrow bands, the tips were in most cases black. The dates of capture were:—July, 1911; 1st August, 1911; 3rd August, 1911; 16th September, 1911; 18th September, 1911; 21st September, 1911.

Anopheles (*Cellia*) *pharoensis*, Theobald. One specimen only. This was taken in the dark-room tent, 3rd August, 1911.

Anopheles (*Pyretophorus*) *costalis*, Loew. Only one example of this mosquito was captured, during the month of August.

Anopheles (*Myzomyia*) *funestus*, Giles. This malaria-carrying mosquito was the most abundant of all the Anophelines observed by us. On July 31st, we decided to fix our permanent camp on the banks of the Shiri, opposite Matutas village, but our tents became so badly infested with this mosquito that we decided to abandon the site, selecting a more open spot a short distance away. Our first camping ground in this locality was surrounded by tall and, for the most part, densely foliaged trees, and was distant from the river about 80 yards. The permanent site of the camp was 200 yards from the water in practically open country. We found, however, that this Anopheline was equally abundant in both places: on August 2nd, one hundred and eleven specimens of this species were counted in one of the tents, and there were certainly an equal number present in the other tent. The temperature on this occasion at 3 a.m. was 46° F., at midday 86° F. in the shade, and at 8.30 p.m. 55° F. On August 9th, one hundred and sixty-two specimens of this species were captured in one of the tents. These consisted of thirty ♂♂, twelve unfed ♀♀ and one hundred and twenty ♀♀ which contained blood. This total does not, however, represent the actual number present in the tent, as large numbers escaped and many remained uncaptured, so that there were probably half as many again as the total captures, and there was certainly an equal number present in the other tent. This was the only occasion on

which we attempted to catch as many individuals as possible with the view of ascertaining the ratio of sexes, the proportion of fed and unfed females, and the approximate number present in the tent. Further captures were made on August 14th and 31st, when twenty-three ♀♀ and three ♂♂, sixty-eight ♀♀ and eleven ♂♂ were captured respectively. We consider that the figures given for August 9th may be taken as representing the approximate numbers present daily in either tent at that period; but we noticed even larger numbers on several occasions. During this time the tents were opened daily at each end, and as many mosquitoes as possible driven out, but as already stated we found no diminution in the numbers. The largest numbers observed were always in the darker portions of the tent, such as the angles of the roof and sides, between the boxes and on various garments. We also observed that they settled freely upon freshly skinned birds, especially guinea-fowls. We also observed on many occasions large numbers flying into the tents in the early morning between dawn and sunrise, the chief point of entrance being at the upper portion of the opening, through which they passed in more or less continuous flight until the rising sun put an end to their movements. Our native employees, about fifty in number, slept in the open about 15 to 25 yards from our tents. The nearest native village being on the opposite side of the river and about half a mile distant, we came to the conclusion that the principal food supply of these mosquitoes was obtained from the natives in our camp.

Mansonioides uniformis, Theobald. It was by far the most abundant of all the mosquitoes, and also the most vicious and persistent biter. It attacked one at any time of the day or night, but was most troublesome shortly after sunset. It simply swarmed along the river and its immediate vicinity, but occurred also in the bush in places far remote from water. It was not, however, 'domestic' in its habits, though a few specimens were taken in our tents during the day. It was equally obnoxious on the lower Shiri; but almost entirely disappeared in the Zambesi where the margin of the river was free from aquatic plants. It is highly probable, therefore, that it breeds chiefly in those portions of the Shiri where the 'sudd' is extensive, and where rootlets and stems of aquatic plants suitable for the attachment of the larvae abound.

Culex tigripes, Grandpré. One female only was taken in one of the tents in our camp during the month of August.

Ingramia (Mimomyia) uniformis, Theobald. One female of this rather rare mosquito was taken at night in our camp on August 11th, 1911. The beautiful pale blue reflections on the thorax were very marked in this example.

Etorleptiomyia mediolineata, Theobald. One female was taken at the camp.

Taeniorhynchus aurites, Theobald. Examples of this species were taken in the camp, the date for which is now lost.

PSYCHODIDAE.

Phlebotomus minutus var. *africanus*, Newst. Three examples of this species were captured during the daytime, while at rest inside the tents; and one at artificial light, at 7.30 p.m. Other specimens, presumably of the same species, were also seen inside the tents at various times generally resting upon the canvas roof. On two occasions late at night examples attempted to bite one of us while under the mosquito net; the familiar high-pitched note, somewhat resembling that produced by a mosquito but much fainter, was heard distinctly as the insects hovered round the face of its would-be victim; on the first occasion we were sleeping under canvas; the second time in our large mud-house.

The first example was taken in the middle of July; the others were seen during August, and the last one towards the end of September. It is evident, therefore, that this insect occurs in Nyasaland during the dry season as it does also in Malta, and possibly also in other parts of Africa.

TABANIDAE.

Tabanus taeniola var. *variatus*, Walker, occurred very sparingly towards the end of August, four specimens only being seen and captured. These were all females. One was captured inside one of our tents, one was caught on a dead hippopotamus, and two were attracted by the fresh, moist mud on the walls of our hut.

Tabanus africanus, Gray. Two females of this handsome species were also attracted by the fresh mud which covered the walls of the hut. None was seen after the moisture had evaporated from the mud.

PUPIPARA.

Echestypus sepiaceus, Speiser. A number of specimens were taken from a young Kudu bull which was killed five miles west of our camp on September 14th, 1911.

Olfersia ardeae, Macq. Two examples of this Hippoboscid were taken from a freshly killed Goliath heron (*Ardea goliath*), August 22nd, 1911. It is an extremely active insect, and the specimens were caught with difficulty.

HEMIPTERA (Family CAPSIDAE).

Trigonotylus brevipes, Jak. This minute green bug was first observed in our camp an hour after sunset, on August 10th, 1911, when it bit one of us severely on the back of the hand; the proboscis being driven so firmly into the skin as to prevent its immediate escape, so that one was enabled to examine it carefully with a pocket-lens. Subsequently this insect occurred in large numbers at irregular intervals during August and September, always apparently attracted by artificial light, and always annoying by its persistent efforts to bite. It cannot, however, be considered a true blood-sucking insect, and we believe that its bites are made out of mere curiosity rather than to obtain blood. In life, it is of an almost uniform grass-green colour, with a narrow, pale streak below the costa of the elytra, antennae dull crimson-red, basal portion of terminal segment with an indistinct greyish ring; eyes black; abdomen vivid green; legs slightly paler, especially the hind femora; terminal segments of tarsi black.

TICKS. IXODIDAE.

Though a number of animals were examined during our stay in the Shiri Valley, comparatively few of them were found infested by ticks. The following is a list of all the species observed.

Rhipicephalus neavei, Warburton. One male and four females from a Kudu, five miles west of camp, 1911, many specimens from a buffalo, 3rd August, 1911; two males and two females off Nswala or Mpala antelope, Upper Shiri Valley, 8th August, 1911; one female off an eland, Upper Shiri Valley, 20th August, 1911.

Rhipicephalus falcatus, Neumann. Off buffalo, 3rd August, 1911.

Rhipicephalus simus, Neumann. Three males from buffalo, Upper Shiri Valley, 3rd August, 1911.

Rhipicephalus maculatus, Neumann. One male from buffalo, Upper Shiri Valley, 3rd August, 1911.

Hyalomma aegyptium, Linn. Off buffalo, Upper Shiri Valley, 3rd August, 1911.

BREEDING PLACES OF ANOPHELINE MOSQUITOES IN FREETOWN, SIERRA LEONE

BY

B. BLACKLOCK

(*Received for publication* 29 *November*, 1921)

PLATES XXVII TO XXXI AND THREE MAPS

Stephens and Christophers (1900) stated 'in Freetown we found that during the dry season the streams were the main source of *Anopheles*.' Daniels (1901), in a letter to Sir Ronald Ross bearing on the anti-mosquito operations then proceeding in Freetown, expressed the opinion that in the dry season, while the surface collections of water would have disappeared, new breeding-places would arise, 'mainly the streams, small and large, which remain, possibly some of the other wells and artificial collections of water in tubs, etc.' Boyce, Evans and Clarke (1905) mention 'the great disadvantage which attaches to the streams in the dry season, viz., that they constitute in Freetown, at that period, the chief sources of *Anopheles* supply.'

With the object of ascertaining whether the streams referred to above, which traverse Freetown, still act at the present day as breeding-places of anopheline mosquitoes, I took the opportunity of examining them at the end of the dry season of 1921. The search for larvae was carried out in the month of May, at which time the stream beds contained comparatively small amounts of water. The plan adopted in making the survey was to start at the mouth of the stream at the point of entry into the sea and to work up stream through the town until the places of origin of the streams was reached in the high ground at the foot of the hills behind the town; the various tributaries were followed in turn.

The results obtained showed that in each stream in which larvae were found, breeding-places were present in largest numbers at the

lower end of the stream; as one proceeded upwards through the town the breeding-places and the numbers found became scanty, while on emerging from above the town breeding places were again found, but still in small numbers in comparison with those at the lower end of the streams.

The reasons for this distribution are doubtless numerous, but some of them are clearly connected with the conformation of the ground. The streams, in some cases, by the time they reach a point several hundred yards from the sea have produced wide, steep-sided gorges through which they pursue a tortuous, irregular course; the numerous sheltered bends, overgrown with grass and weed, afford excellent breeding-grounds and shelter for the larvae. The process of erosion in the wet season appears to have more than compensated for the additional volume of water to be carried, so that the advantage of flushing is to a certain extent lost in the lower portions of the streams. In the town proper the streams are passing through a rocky formation, with the result that there is slower erosion; this and the great amount of canalisation of tributaries which has been carried out in recent years permit of more complete washing out of the stream bed in its passage through the town. Above the town the prevalence of larval breeding-places was to be anticipated from the more diffuse nature of the water courses, their extensive area, and the plentiful vegetation through which the water slowly percolates before forming definite streams. The conformation of the ground, while it favours the presence of *Anopheles* by providing suitable breeding-places, acts also in their favour, especially in the gorges mentioned above, by rendering it difficult to obtain access to these breeding-places for the purpose of detecting them, and still more by rendering the application of the measures necessary for their eradication very laborious.

The maps appended show (Nos. I and II) the places in which anopheline larvae were discovered and the manner of their distribution in 1921 and 1900. It was observed that the residual breeding-places in the streams at the end of the dry season are of two kinds. The first is the edge of the winding and eroded bed of the stream just before its entrance to the sea, the second is the shallow water, well protected by vegetation and extending over a large surface, which is found at the places of origin of the streams. These residual

PHOTOGRAPH No. 1

Anopheline breeding place, in the town. The man is standing in the water at the point in which *A. costalis* larvae were found. Note native house in the background, water sluggish.

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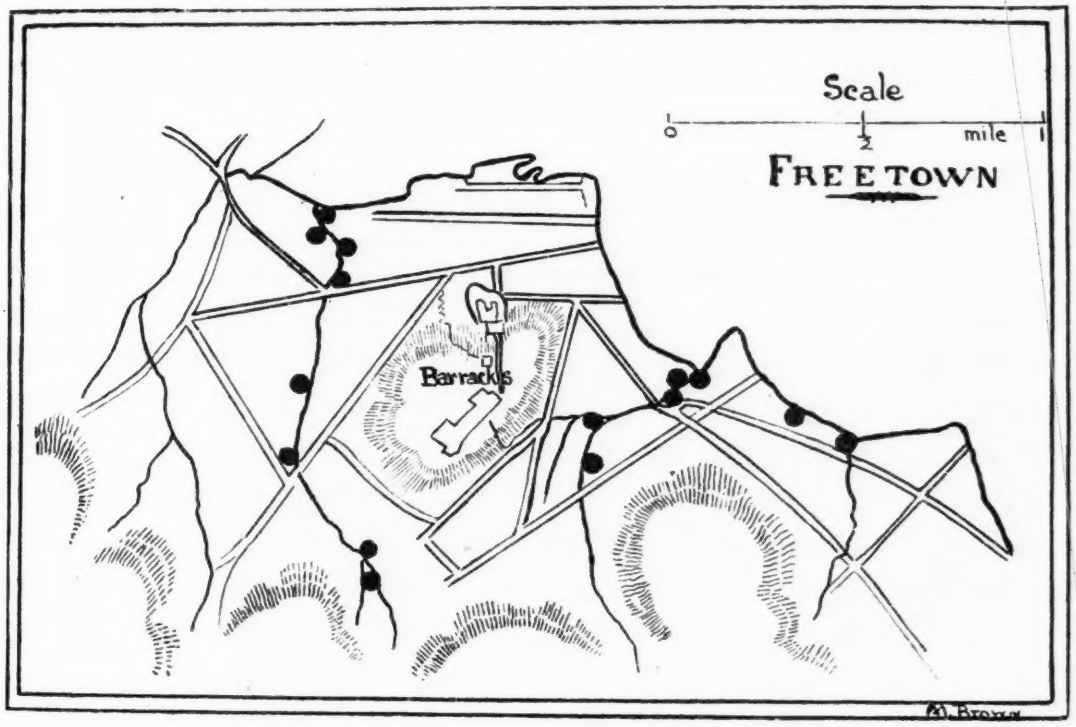
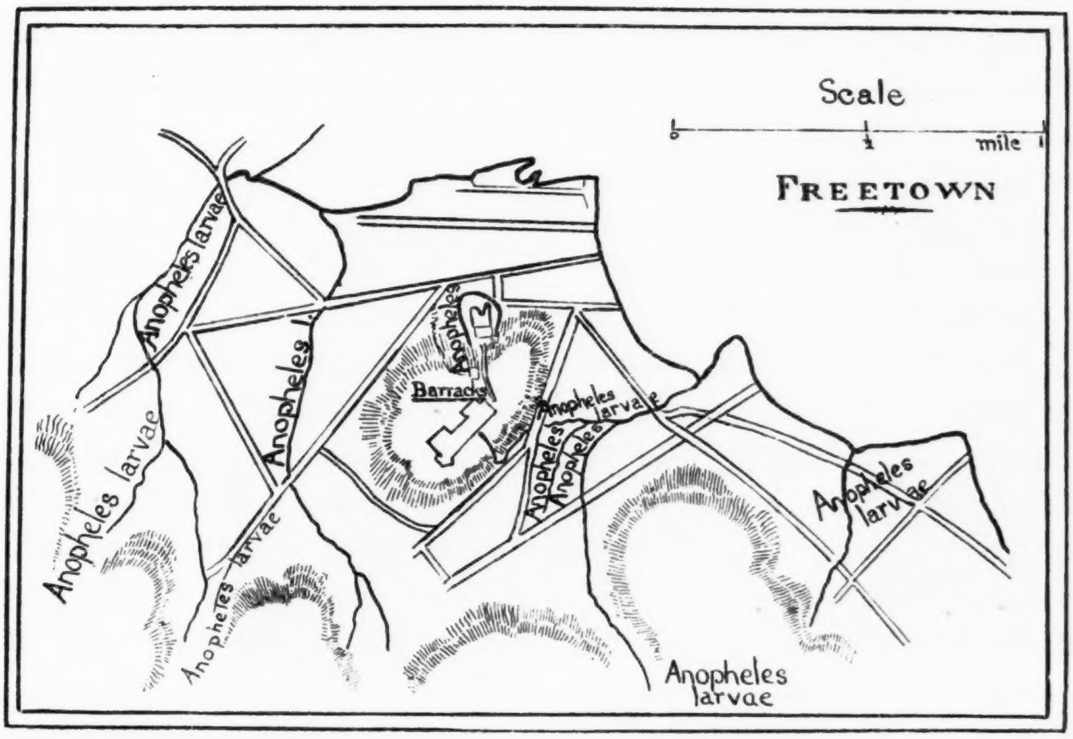


MAP 1. ● *A. costalis* larvae or pupae found 1921.



MAP 2. Anopheles larvae found 1900.

breeding-places doubtless contribute very materially to the spread of *Anopheles* when the rains commence, and other breeding sites become available. Some of the more interesting breeding-places found are seen in photographs 1 to 5.

SPECIES OF *ANOPHELES* FOUND

Larvae and pupae collected from the various breeding-places were taken to the laboratory and allowed to develop; anophelines which emerged belonged in all cases to the species *A. costalis*. This appears at the present time to be by far the commonest anopheline breeding at the end of the dry season in Freetown. It is deserving of note that in the early days of mosquito investigation in Freetown this species predominated at the end of the wet season also. Daniels (1901) mentions *Anopheles costalis* as a common mosquito in Freetown, and further states that '*A. funestus* was found near but not in Freetown.' Ross, Annett and Austin (1902) stated that while of over two hundred anophelines obtained from Wilberforce Barracks all were *A. costalis*, they obtained from Dr. Berkeley at Kissy both this species and also *A. funestus*, the latter 'by far the more numerous.' They add that *A. funestus* was restricted entirely to the eastern part of the town, and that they never found a larva or an adult of this species west of Government House. It is not stated, however, how near to this dividing line *A. funestus* existed on the east side at that time. Thus, while there is no evidence from the foregoing and the present survey that the proportion of *A. funestus* to *A. costalis* has undergone a change during this period of years, there is considerable evidence to show that *A. costalis* was then, and is to-day, the commonest anopheline in Freetown. Owing to lack of time, little could be done in the way of dissections of adults, either caught wild or experimentally fed on malaria carriers; this will be reserved for a further date, when it will be of great interest to discover whether there exist to-day any rates of mosquito infection comparable with the Wilberforce Barracks figures of Ross and collaborators in 1902, namely, twenty-seven infected *Anopheles costalis* in one hundred and nine captured females dissected.

PHOTOGRAPH No. 2

Anopheline breeding place, above the town. The water is sluggish and almost concealed by vegetation. Numeroas *A. costalis* larvae found to left of man.

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It may be said then that the results obtained in 1921 at the end of the dry season were such as to confirm the predictions of twenty years ago, and in view of the great amount of careful and painstaking work which has been steadily carried out in the interval with a view to abating mosquito breeding, it is clear that in these streams we have a problem which will require a little more detailed investigation.

METHODS OF DEALING WITH THE STREAMS

Previous suggestions as to how such an obvious source of *Anopheles* could be dealt with have been of various kinds. Some of these may be mentioned.

Daniels (1903) wrote: 'Two possible methods which are most obvious are the formation of a central channel in the bed of the stream, with larger collections of water in sufficient numbers of places for drinking purposes, and, lower down the stream, other places for washing, etc. The second, which might be cheaper but certainly less effective, would be to dam up the streams so as to obtain a sufficient head of water to flush out the whole channel at intervals.'

Boyce, Evans and Clarke (1905) summarised their views on this matter as follows:—

(1) Reconstruction of the bed of streams.
(2) Diversion of water for flushing of town drains in dry weather.
(3) Construction of dams in streams and flushing of beds at intervals.

It will be seen that schemes one and three here correspond to the two suggested by Daniels above. The town drains referred to, in number two, are the surface drains in the streets.

(1) *Reconstruction of the bed of streams.*

If one follows such a stream as Nicol's Brook from its origin above Foulah town to the point where it enters the sea, it is realised that the operations involved in this scheme would be of great magnitude. The process of erosion has been so irregular in its action that the water does not flow on a simple slope from above down to the sea

level. It forms at places considerable falls, and also has cut very large cavities in the bottom of the stream bed. Laterally also it extends in different places to very different dimensions. In order to rectify the levels and build a channel capable of carrying all the rainy season water, it appears that a very large expenditure would be involved. If when this expenditure had been made the streams could then be regarded as safe, it might be a plan worthy of consideration : but it appears probable that constant attention would be required to ensure that the lateral tributaries discharged properly into the central channel and that pools did not form outside this channel itself. This would involve one of two things. Either the channel would have to be so levelled and sloped at the sides that no pools could possibly form—a vast operation—or else such pools would have to be treated regularly with larvicide, as at present. The other streams would require similar measures.

(2) *Diversion of water for flushing of town drains in dry weather.*

This scheme would, it appears to me, fail to be effective in preventing anopheline breeding in the stream beds, for two reasons. One is that water oozing out of springs between the strata in the bed of the stream would still form pools suitable for breeding anophelines. The other is that many of the drains referred to discharge into these streams and would thus carry the water back to the bed of the stream after having flushed out the town street drains.

(3) *Construction of dams in streams and flushing of beds at intervals.*

This scheme assumes that the bed of the stream is capable of being effectually flushed, but the observations which were made above in connection with the conformation of the streams go to prove that Nature has already by the process of excavation and erosion effectually prevented such a flushing action being successful. Further, it cannot be said that even a large volume of water passing occasionally down a river bed which is a honeycomb of pools will ensure the sweeping out of anopheline larvae from these pools. This scheme, therefore, does not appear to guarantee success.

PHOTOGRAPH No. 3

Anopheline breeding place, in stream bed in the town. *A. costalis* larvae found near bank to left of where the woman is standing.

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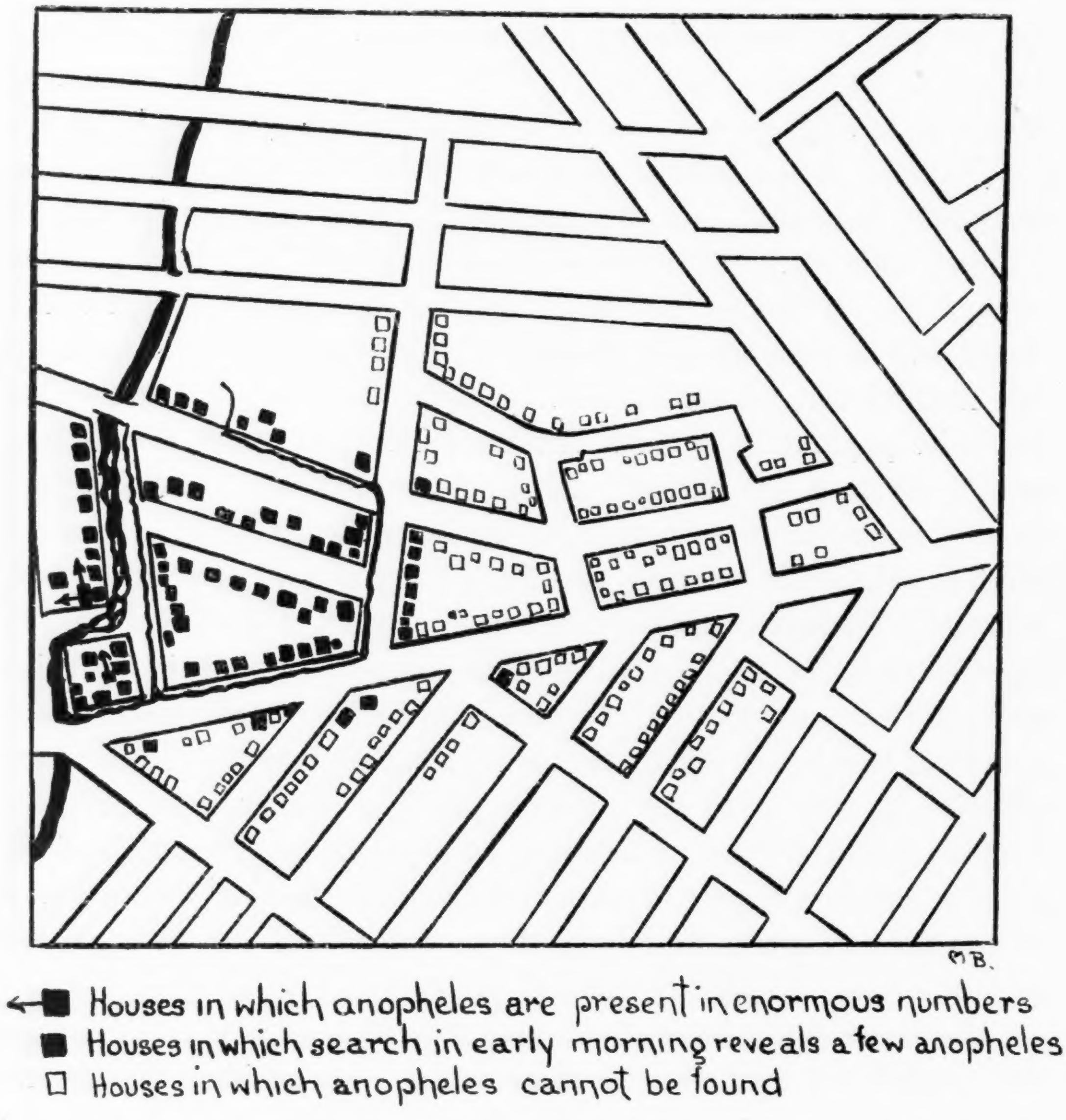
SEGREGATION METHOD

Stephens and Christophers were among the pioneers of the segregation method of dealing with the malaria problem, and there is ample evidence of the efficacy of this method where it is vigorously and thoroughly carried out. It is chiefly of value where we are dealing with a small non-immune community which has to exist side by side with an overwhelming preponderance of immunes and semi-immunes. It is based on the fact that there always has been, and always is, a large proportion of infected children among the native population. If we believe such conditions will always remain in the future, it is clear that the readiest and most inexpensive way of dealing with such a small white community will be by strict segregation; in this way a great degree of safety from infection can reasonably be insured. In places which are being newly developed this method can be used advantageously, as also in places where the white population is small and circumstances favour their settlement away from the native. But in old established towns it is not by any means an easy method to apply, more especially where the white population is growing, and likely to grow greater year by year. It is also a method which leaves the natives to themselves and frankly regards them as so infected that no immediate and inexpensive mode of dealing with this infection is available; to this extent it is a method which is a tacit acknowledgment of defeat. Segregation occupies in respect to the malaria problem much the same place from the point of view of medical prophylaxis as evacuation of fly areas occupies in respect to the trypanosomiasis problem. Each may be excellent as a temporary expedient, but neither can be regarded as a final and satisfactory method of dealing with these problems.

The bearing of segregation on the question of how to deal with the streams of Freetown is clear when we consider the results obtained by Stephens and Christophers in their investigation on the anopheline content of these streams and the native houses situated close to them. I have obtained the permission of these authors to reproduce a spot plan (Map III) which they made in 1900, showing the distribution of adult anopheles in houses near such a stream. It will be observed that 'houses in which anopheles are present in enormous numbers' are found immediately beside the stream, that

'houses in which search in early morning reveals a few anopheles' extend back from the stream a short distance, while as we recede further from the stream we reach 'houses in which anopheles cannot be found.' The conditions depicted here would, I feel no hesitation in saying, reproduce themselves automatically immediately any considerable relaxation of the present sustained effort on the part



MAP III.

of the sanitary authorities of Freetown took place. In Freetown it does not appear to me practicable now to adopt a method of rigid segregation, and moreover, even if it were practicable, it would still be advisable to deal with the problem of the streams with a view to ameliorating the condition of the native.

PHOTOGRAPH No. 4

Anopheline breeding place, in the town. A few *A. costalis* larvae were found at points along the edge from where the man is standing; water fairly rapid.

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IS A PERMANENTLY EFFECTIVE SCHEME POSSIBLE?

The only permanent scheme which will be effective in dealing with the stream beds appears to be one which obliterates them entirely. Whether any such scheme can be devised is a matter for engineers to determine. It might involve the construction of a canal or canals capable of carrying the water to east and west from above the town and reclamation of the present stream beds. The fact that the outlay required, if the scheme were practicable, would be very large indeed does not enter at present into the discussion. Whether the effective method will prove too costly need and can only be decided after considerable investigation over a period as to whether an effective scheme is practicable from the engineering point of view. It deserves investigation, however, even if apparently excluded on account of prohibitive cost, for we are not justified in assuming that an effective method which would be too expensive at present must necessarily prove so in future years.

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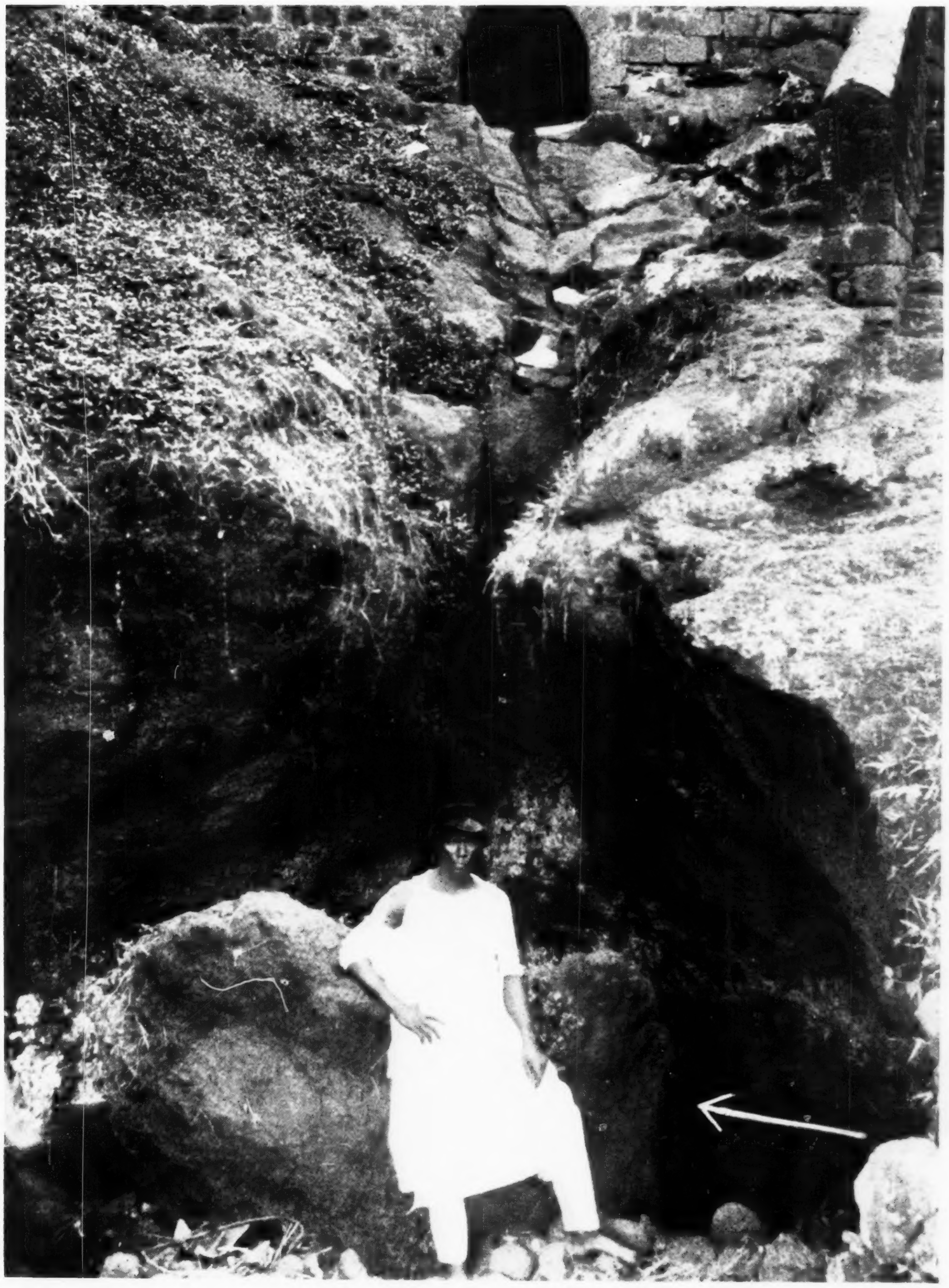

PHOTOGRAPH No. 5

Anopheline breeding place, in the town. Behind the rock in front of which the man is standing is the pool in which little vegetation was present; a few *A. costalis* larvae.

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NOTES ON AN APPARATUS FOR THE INDIVIDUAL BREEDING OF MOSQUITOES

BY

B. BLACKLOCK

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The apparatus here described is designed to facilitate the task of breeding out mosquitoes individually from any stage in which they happen to be at the time when they are collected, and in this way obtaining a record of the association of the various stages. It is a development of the breeding apparatus which Carter and Blacklock (1920) described, and its small size makes it easily portable and convenient for use in the tropics. By means of it, with a little trouble, a complete record of the stage originally obtained, the adult stage, and the intervening stages is possible. The parts of which the apparatus consists are glass capsules of suitable size, embedded in a wooden base, glass cylinders of which one end is covered with mosquito netting, and glass tubes for the collection of the casts at the various stages of development. It will be simplest to give the dimensions of the model actually in use; this has proved, in so far as mosquitoes are concerned, satisfactory, the mortality, whether of larvae, pupae or adults, being comparatively small. Modifications could easily be introduced which would render the apparatus suitable for observing the development of other insects in their aquatic stages.

The capsules. These are made from glass tubing, and are of the following dimensions:—Internal diameter, 11 mm.; internal height, 18 mm. They are of stout glass, about 1 mm. thick, rounded at the bottom like a test tube (fig. 1), and they fit into holes drilled in the

FIG. 1.

wooden base at measured intervals. The depth of the hole bored is such that when a capsule is placed in it the edge of the capsule lies

flush with the surface of the board, and the width of the holes is such that it is possible with fine bladed forceps to lift the capsule out of the board. A small ring of plasticine can be used to fit the junction of the holes that are too large for the capsules.

The board. The wood used in making the board is hard and well seasoned so that it will not warp. The length is 30 cm., the width 11 cm., the depth 3 cm.; the holes are bored in three rows, the distance between the holes from each other in any row or between the rows being 2 cm. (fig. 2). In this manner it is possible to have

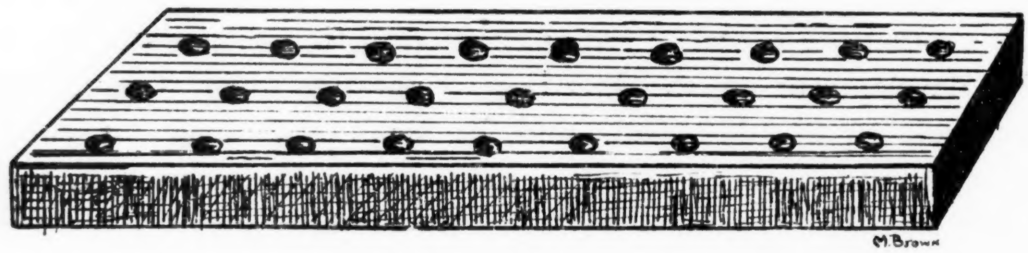

Fig. 2.

in each board twenty-seven capsules arranged in three rows of nine capsules each. In boring the holes, the first row is bored near the edge of the wood, leaving a rim of only about 0·5 cm. in front of them; the object of this arrangement will be explained later when describing the manner of using the apparatus.

The cylinders. These are made of glass, of similar thickness to that used for the capsules. The dimensions are:—Internal diameter, 15 mm.; height, 25 mm. It is essential that one end at least of the cylinder should be so cut that it will stand upright and make fair contact all round its edge with the board on which it stands, if one end is irregular, it should be used as the upper end; this end is in all cases covered with a small piece of mosquito netting, kept in position by a piece of string or two thin rubber bands (fig. 3).

Fig. 3.

As rubber is apt to deteriorate in the tropics and a band may break, it is necessary when using such bands to use two to ensure safety; string, however, answers the purpose quite satisfactorily, merely taking a little more time to fix on and take off. Fig. 4 gives a

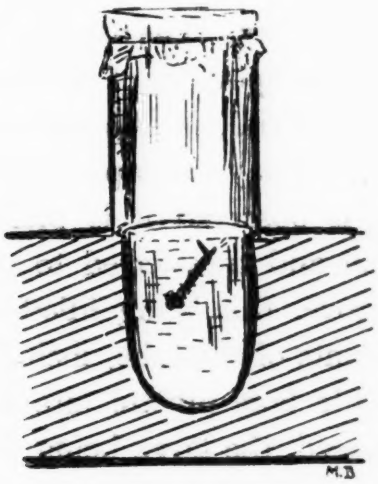

FIG. 4.

section of the cylinders in position covering the capsule embedded in the board.

Tubes for casts. These are made from glass tubing of an internal diameter of not less than 5 mm. and about 6 cm. in length, drawn to a blunt point at one end (fig. 5). When the larval and pupal

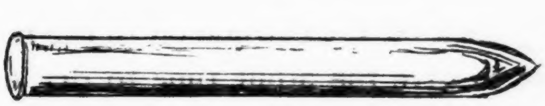

FIG. 5.

pelts have been placed in them they can be corked and waxed, or better, if so long as to permit of it, they can be drawn out in a small flame and sealed.

Method of use. The stages collected in the field, and from which it is desired to breed adults, are placed in a dish of such a size as to render it easy to ensure the isolation of individuals, and one by one these are transferred to the capsules, each into one capsule; this is filled with water and replaced in its position in the board, as evaporation occurs the fluid lost must be replaced daily to keep the water at the surface level. This is especially necessary in the case of anopheline larvae. The capsule is marked by a number written

on the board in front of it in pencil, the same number being entered in the book in serial order. The front of the board is that margin on which the narrower rim is left; this serves to identify the front, and is useful in practice also by leaving standing room at the back of each capsule for the accommodation of the cylinders when they are removed from their capsules. The capsule having been filled with water and replaced, a small portion of dried, powdered cockroach, or other suitable food material, is deposited on the surface of the water with a needle. Each day the capsule is examined at intervals, and when a cast skin is observed it is picked out with a needle or fine camel-hair brush and transferred to one of the tubes which have been described above, this being filled half full of preserving fluid, or the whole contents of the tube, including the larva, may be pipetted out with a wide bore pipette into a small porcelain dish and the cast skin recovered, the larva being replaced. Transfer by means of a pipette is apt to lead to difficulties owing to the fact that whereas the larval pelts usually fall to the bottom, the cast pupal skins usually float and may become stranded on the side of the pipette used. The date of the stage is noted in the record, the tube is numbered with the same number as the capsule and is retained for all material which is derived from that capsule. As soon as the pupal stage is reached one of the cylinders is placed in position over the capsule, and when the adult emerges into the cylinder this may be pushed carefully back off the capsule on to the board immediately behind it, in order to give the adult time to dry and expand. At the same time the pupal cast is removed and placed in its tube, which is then corked and waxed or sealed over a flame. When the adult is ready for pinning it is removed from the board by slipping a strip of thin, stiff paper underneath the cylinder containing it, chloroformed by sliding the cylinder on to a piece of paper moistened with chloroform, while the upper end of the cylinder is covered by the finger; when pinned it is labelled in the collecting box with the same number as the capsule from which it was derived and the tube containing its other stages. Before use again after one experiment the capsule is carefully swabbed out with a pledget of cotton wool, first with water, then with alcohol, and dried.

In this way it is possible to obtain in the majority of cases a very complete record of the stages from the time the individual was

collected; the apparatus is of value, not only as a simple means of associating stages and noting their duration in the laboratory, but also for isolating mosquitoes as they emerge if required for experimental purposes.

Precautions in use. Care is required with reference to the following points:—

(1) Proper entry in the record of the number given to the capsule, pelt-tube and adult.

(2) That one individual only is introduced into the capsule; this is especially necessary when dealing with young larvae or eggs.

(3) That each pelt is removed as soon as it is shed.

(4) That the tube containing pelts is well sealed if intended to be kept for future examination.

THE TREATMENT OF A CASE OF RHODESIAN SLEEPING SICKNESS BY THE PREPARATION KNOWN AS 'BAYER 205'

BY

WARRINGTON YORKE

(*Received for publication* 6 *December*, 1921)

The patient (G. J.) contracted the disease in the Seringe district of North Eastern Rhodesia on the Congo Zambesi Watershed. He was suddenly taken ill on 17th September, 1920, with severe headache, pains in the back and neck, great prostration and a temperature of 105° F.; during the first eight days of the illness the temperature varied between 104° F. and 106° F. Trypanosomes were found in the blood on 27th September, and the patient was thereupon sent to Broken Hill, where he arrived on 24th October, and was treated by Dr. Wallace with tartar emetic, intravenous injections (2·5 to 3 grains) being given every other day. A little later intramuscular injections of antimony oxide ($\frac{1}{50}$ grain) and soamin (2 grains) were also given. Between 24th October and 26th December 3·28 gm. of tartaric emetic, 0·1 gm. of antimony oxide and 2·47 gm. of soamin had been administered, with only a moderate degree of benefit to the patient: trypanosomes were frequently found in the blood and there were several severe febrile disturbances. Between 26th December and 15th January, 1921, thirteen injections of stibenyl (in all 3·05 gm.) were given. These injections were, however, badly borne, and as trypanosomes were present in the blood on 16th January, the original treatment, with tartar emetic, antimony oxide and soamin, was resumed. Things improved somewhat, and on the 3rd February the patient was well enough to leave for England. At Cape Town, and on the voyage, he had further injections of tartar emetic.

When the patient reached Liverpool on 12th March, he was in fairly good condition; trypanosomes were not present in his blood

(inoculated rats did not become infected), there was well-marked autoagglutination of the erythrocytes, and the weight was 144 lbs. Daily examinations of the blood were negative until 18th March, when a few trypanosomes were found. Inoculation of rats showed the parasite to be *T. rhodesiense*. Intravenous injections of tartar emetic in doses of from 2 to 3 grains were then given on alternate days. Neither these nor injections of atoxyl, however, seemed to exert any influence on the course of the disease. Violent febrile disturbances accompanied by severe headaches and great prostration, and the appearance of trypanosomes in the peripheral blood in considerable numbers, occurred with the utmost regularity every five or six days, and the patient went steadily down hill.

In view of the fact that the infection appeared to be antimony and arsenic resistant, I endeavoured to obtain from Professor Mayer, of the Hamburg School of Tropical Medicine, a small quantity of a preparation called 'Bayer 205', manufactured by the firm of Friedr. Bayer & Co., Elberfeld. Although this drug—the constitution of which was not disclosed on account of the state of the Germany chemical industry—had not been used in any case of human trypanosomiasis, it had been employed with remarkable results in the treatment of experimental trypanosomiasis of animals, records of which had been recently published by Haendel and Joetten (1920) and by Mayer and Zeiss (1920).

Professor Mayer informed me that he was unable to comply with my request to let me have a supply of the drug for trial, but stated that if I sent the patient to Germany they would be glad to treat him at the Hamburg School. This, unfortunately, resulted in some loss of time, as I did not like the idea of sending the patient to Germany to be treated with a proprietory article, the composition of which was not disclosed and which could not be sent out of the country. However, as notwithstanding the most rigorous treatment the patient's condition got steadily worse, I went critically through the above mentioned papers again and was so impressed by the results recorded, that I overcame my own scruples and those of the patient, with the result that he left for Hamburg on 5th July, 1921. During his eight and a half months illness the patient had received, in addition to the other drugs mentioned, 22·7 gm. of tartar emetic, and at the time he left for Hamburg his weight had fallen to

132 lbs., he was suffering from frequent violent febrile disturbances, antimony and arsenic preparations were without any effect on the course of the infection, and the condition seemed almost hopeless.

The following details of the case are taken from a recent paper by Mühlens and Menk (1921), under whose care the patient was when in Hamburg. On 9th July, two days after his arrival, he had a rigor, accompanied by headache and fever, and trypanosomes were found in the blood. Treatment was immediately commenced, 'Bayer 205' 0·5 gm. in 5 per cent. solution being given intravenously. The injection was well tolerated; the fever subsided in six hours instead of in the customary thirty-six hours, and trypanosomes had disappeared from the blood within sixteen hours. The next day a second injection of 1 gm. in 10 per cent. solution was given, and this was repeated on the following day: both injections were well borne and the urine remained free from albumen or casts. The blood was examined twice daily during the following seven days, with negative results, and a further injection of 1 gm. was then given. As a small quantity of albumen and occasional red and white blood corpuscles appeared in the urine, no further treatment was administered. The patient improved remarkably, rapidly regained his sense of well-being and put on weight. Almost daily examinations of the blood were made, until 29th August, but with negative results: there were no further febrile attacks or any other untoward symptoms, and on 13th September the patient returned to Liverpool.

When I saw him on 15th September, I was greatly impressed with the remarkable improvement in his general condition: he had lost the anxious and weary expression which had been so characteristic for some months before he went to Germany, his weight had increased to 145 lbs., the blood was negative and sub-inoculated rats did not become infected, and the autoagglutination of the erythrocytes had disappeared. The urine contained a trace of albumen, otherwise the patient seemed perfectly well. The following day he left Liverpool for his home in South Wales. On 5th November, 1921, he returned to Liverpool for further examination. He appeared in excellent health, and stated that he never felt better in his life and had played two rounds of golf daily without the slightest distress. The blood was examined microscopically and also inoculated into three rats,

with negative results: there was no autoagglutination of the erythrocytes or any other sign of the disease: the weight had increased to 150 lbs. (patient's normal weight), the urine, however, still contained traces of albumen. On 11th November he sailed for South Africa.

The above record is of peculiar interest, as it relates to the first case of human trypanosomiasis treated with adequate doses* of 'Bayer 205'. Whilst recognising that hasty and premature claims of success in the treatment of a disease like sleeping sickness are to be deprecated, and that the further history of the patient alone can decide whether a real therapia *sterilisans magna* has been effected, the facts that the disease was of at least eight and a half months standing at the time of treatment with 'Bayer 205'; that the patient was extremely ill and had been getting steadily worse for months, that the infection was completely resistant to the ordinary preparations of antimony and arsenic; that since the administration of 'Bayer 205' all symptoms of the disease have disappeared, the general condition of the patient has improved enormously, his weight has increased by 18 lbs., his blood has been free from parasties and non infective to rats for an observation period of four months—these facts, considered in the light of the usual history of cases suffering from *T. rhodesiense*, warrant the hope that in 'Bayer 205' we have a drug of exceptional trypanocidal power.

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* Mühlens and Menk (loc. cit.) give details of the administration of the drug to a case of *gambiense* infection in March, 1920, but only two small doses (0·2 gm.) were given at an interval of a week. A relapse occurred and the patient was then treated with other drugs.

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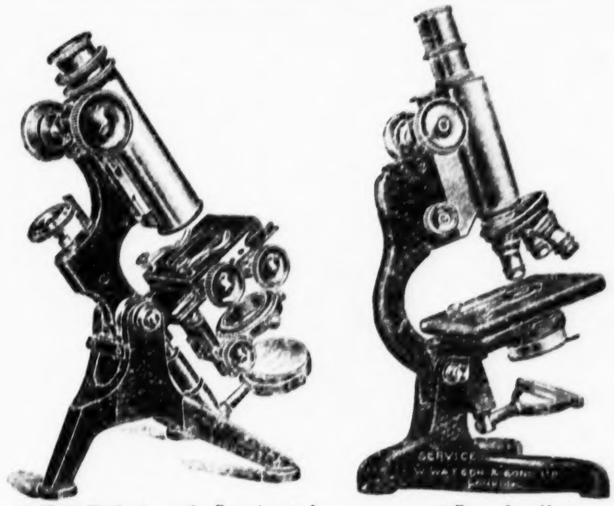

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